# ELF Communications System Ecological Monitoring Program: Electromagnetic Field Measurements and Engineering Support--1990

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The ELF Communications System enables the U.S. Navy to communicate with submarines worldwide at operational depth and speed. The system consists of transmitting facilities in Wisconsin and Michigan that synchronously broadcast messages. Transmitters became fully operational in Wisconsin in 1985 and in Michigan in 1989.

In-situ studies to monitor for possible bioelectromagnetic effects from operation of both transmitters were initiated in 1982. The studies use a split-plot or blocked strategy to examine differences in space (treatment/control sites) or time (preoperational/operational). Physiological, developmental, behavioral, and ecological variables for dominant biota in upland, wetland, and riverine habitats near the ELF System have been examined in these studies. In Wisconsin, data collection for all studies was completed by the end of 1989; in Michigan, studies continued during 1990. It is anticipated that data collection will continue at Michigan study sites through 1993.

In support of this research, IIT Research Institute annually documents the ambient ELF electromagnetic (EM) environment, including EM fields produced by both the ELF System and electric power distribution (60 Hz). This report documents ELF EM field intensities at all study sites active in 1990, and is comprehensive for the period 1983-1990. Other engineering activities performed during 1990 in support of the ecological studies are also described.

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## FOREWORD

This report documents measurements of extremely low frequency (ELF) electromagnetic (EM) fields made in support of the U.S. Navy's ELF Communications System Ecological Monitoring Program from 1983 through 1990. The report also describes other engineering activities performed in support of the Program during 1990. This work was funded by the Space and Naval Warfare Systems Command, Submarine Communications Project Office, under Contract Numbers N00039-81-C-0357, N00039-84-C-0070, and N00039-88-C-0065, to IIT Research Institute (IITRI). IITRI measurement personnel during 1990 were Messrs. D. P. Haradem, J. R. Gauger, R. G. Drexler, M. W. Zankl, and D. M. Kalafut, and Dr. J. E. Zapotosky.

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# 1. INTRODUCTION

## 1.1 Ecological Monitoring Program

In 1981, concurrent with its decision to complete construction of an Extremely Low Frequency (ELF) Communications System, the Department of the Navy established an Ecological Monitoring Program. The purpose of the program is to determine whether long-term exposure to electromagnetic (EM) fields produced by the communications system will result in adverse effects on resident biota or their interrelationships. Monitoring studies are being performed by investigators from several universities, and their efforts are being supported by IIT Research Institute (IITRI).

IITRI assists the investigators by making EM field measurements and providing other engineering support. EM field measurements are needed to ensure significant differences in EM exposure between paired study sites and to provide data that may be needed for further examination of possible cause-and-effect relationships. Engineering support provided by IITRI includes design, fabrication, and installation of EM control and recording equipment for culture chambers; mitigation of EM exposures in laboratories; and mitigation of on-site ambient monitoring equipment with respect to EM safety, EM interference, and damage from nearby lightning strikes. IITRI personnel also summarize data on the operational characteristics of the ELF transmitters, and review the use of EM data in reports by investigators. All of these support activities are documented annually in IITRI technical reports.

This report documents engineering support activities during 1990 and provides a comprehensive summary (1983-1990) of EM exposures at study sites and laboratories that were still active in 1990. Documentation of EM field measurements and engineering support for completed studies, namely the wetlands, slime mold, and bird species and communities studies performed in Wisconsin, appears in previous annual reports.[1-7] Final reports for the Wisconsin studies have also been published.[8-10]

## 1.2 ELF Communications System

The ELF Communications System consists of two transmitting facilities, one located in the Chequamegon National Forest in Wisconsin and the other in the Copper Country and Escanaba River State Forests in Michigan (see Figure 1). Each facility consists of a transmitter connected to long overhead wires (antennas) with buried ground terminals at their ends. Both the antenna and grounding elements are located in cleared rights-of-way (ROW). The Naval Radio Transmitting Facility-Clam Lake, Wisconsin (NRTF-Clam Lake) consists of a north-south (NS) and an east-west (EW) antenna, each 14

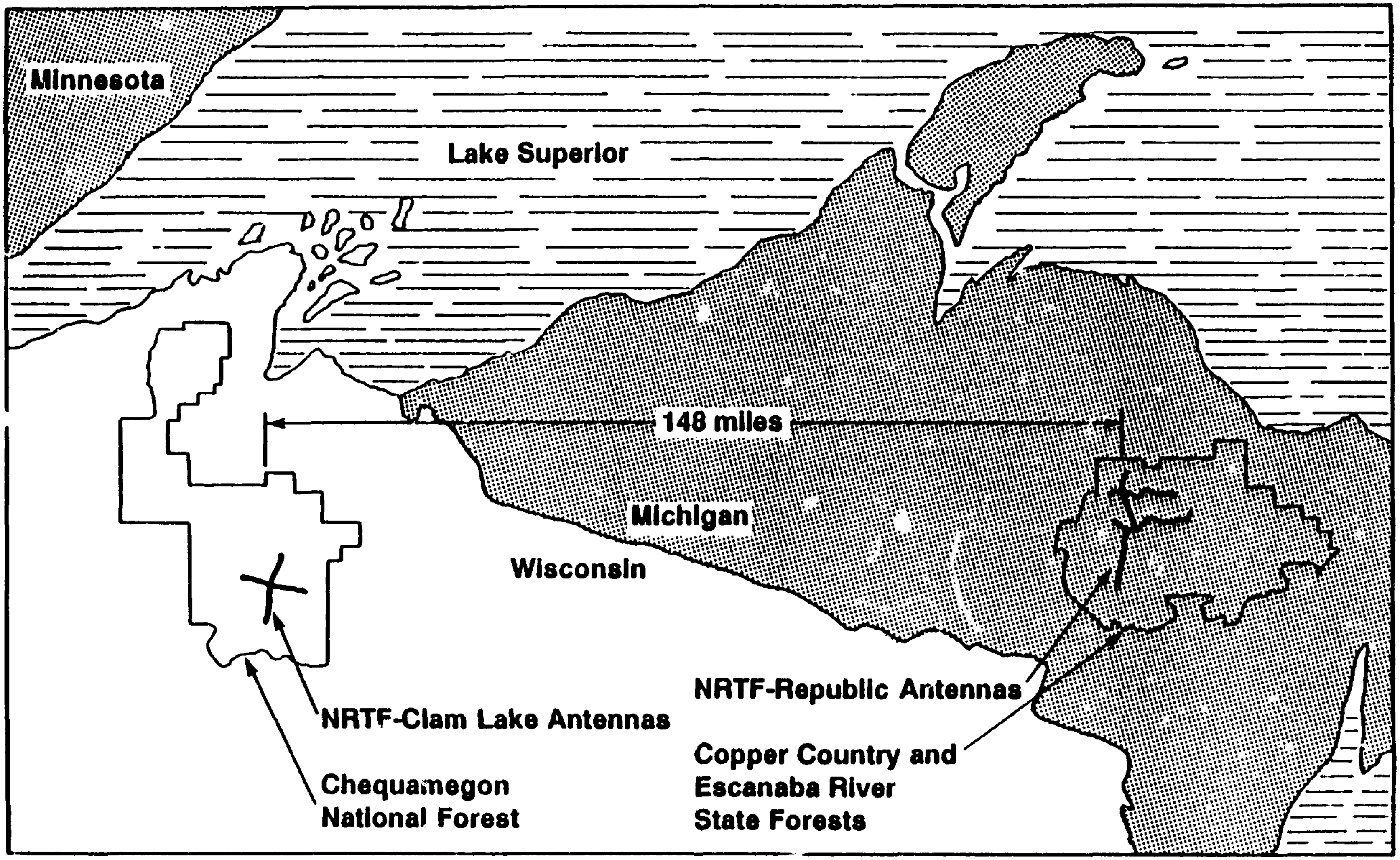



FIGURE 1. ELF COMMUNICATIONS FACILITIES IN WISCONSIN AND MICHIGAN.

miles long. The Naval Radio Transmitting Facility-Republic, Michigan (NRTF-Republic) consists of a 28-mile-long NS antenna and an EW antenna comprised of a northern east-west (NEW) and a southern east-west (SEW) element, each of which is approximately 14 miles long. The end of each antenna or antenna element terminates in one to three miles of buried horizontal ground wire and one or more arrays of vertical electrodes 100 to 300 feet deep.

The transmitters broadcast messages using ELF EM fields; these fields are the operational component to be evaluated by the Ecological Monitoring Program. The EM fields produced by the ELF Communications System are:

- a magnetic field, essentially the same in the air and the earth, that is generated by the electrical current in the antenna elements and ground terminals
- an electric field in the earth that is the sum of the fields induced by the magnetic field and the current flowing from the buried ground terminals
- an electric field in air that is produced as a result of the difference in potential between the antenna element and the earth

The frequency produced by an operational ELF Communications System is modulated using minimum shift keying (MSK), a special form of frequency shift keying. An important aspect of MSK modulation is that minimal energy is generated outside the signal bandwidth. The transmitted message is binary coded: If a zero is to be transmitted, the frequency of the current is 72 Hz; for a one, the frequency is 80 Hz. The center frequency is therefore 76 Hz, and is the frequency with the greatest power spectral density. The planned frequencies for routine operation of the ELF Communications System are modulated between 72 and 80 Hz; in addition, the system can transmit at frequencies between 40 and 48 Hz (44 Hz center frequency). Figure 2 illustrates an MSK waveform and its corresponding binary code and power spectral distribution.

Exposure of resident biota to 76 and 44 Hz EM fields has been quite variable over the development of the ELF Communications System. In order to address these differences, some ecological investigators have divided EM exposure into preoperational, transitional, and operational periods. During the preoperational phase, biota received no EM exposure from the ELF system. The transitional phase began with the intermittent energizing of transmitters for testing, most often at intensities lower than those of a fully operational ELF system. During the operational phase of the ELF system, EM exposures are nearly continuous and at planned, full-power intensities. The NRTF-Clam Lake was first energized in 1969 and became fully operational during the last quarter of 1985; the NRTF-Republic was first energized in early 1986 and became fully operational during the last quarter of 1989.

### 1.3 Paired-Site Concept

In order to examine for possible effects, the monitoring program employs a split-plot design that compares data collected at a control site with data collected at a treatment site. The paired sites have

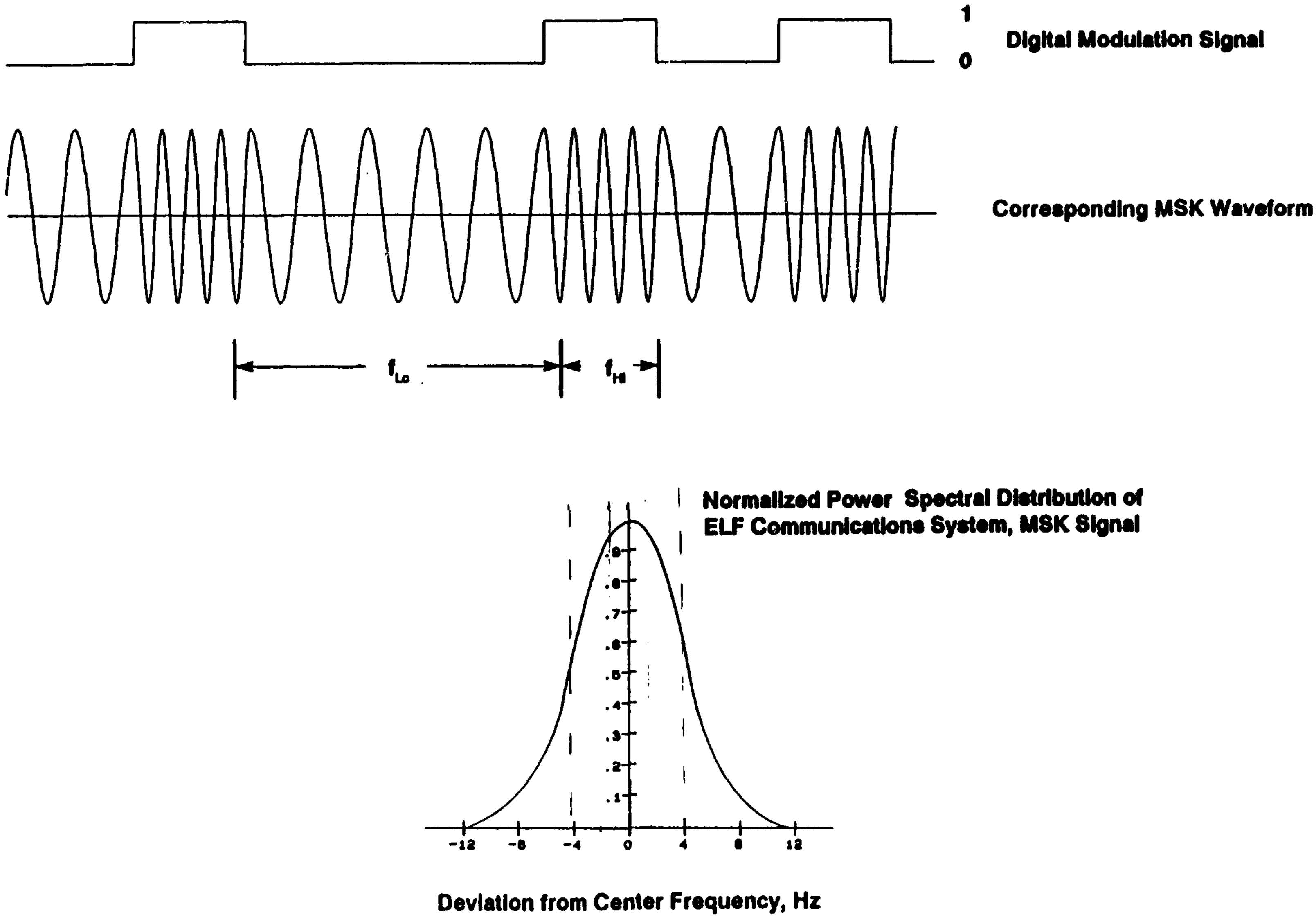



FIGURE 2. MSK WAVEFORM AND POWER SPECTRAL DISTRIBUTION.

matched biotic and environmental factors, but purposely dissimilar 76 Hz EM exposures. The control site is used to measure the effects of environmental factors on study variables. Variables at the treatment site express the effects of environmental factors as well as possible effects from exposure to higher 76 Hz EM fields.

Dissimilar 76 Hz EM exposures were attained by situating treatment sites relatively close to the ELF Communications System while placing control sites at a greater distance. The EM exposure criteria used in site selection are expressed in equation form as follows:

$$T_{(76\text{ Hz})}/C_{(76\text{ Hz})} > 10 \tag{1}$$

$$T_{(76\text{ Hz})}/T_{(60\text{ Hz})} > 10 \tag{2}$$

$$T_{(76\text{ Hz})}/C_{(60\text{ Hz})} > 10 \tag{3}$$

$$0.1 < T_{(60\text{ Hz})}/C_{(60\text{ Hz})} < 10 \tag{4}$$

where $T_{(76\text{ Hz})}$ = test site exposure due to ELF Communications System
$T_{(60\text{ Hz})}$ = test site exposure due to power lines
$C_{(76\text{ Hz})}$ = control site exposure due to ELF Communications System
$C_{(60\text{ Hz})}$ = control site exposure due to power lines

By means of these criteria, the monitoring program sought to ensure that the intensities of the 76 Hz EM fields at treatment sites were significantly greater than those at control sites (Equation 1); that the 76 Hz EM field intensities at treatment sites were significantly greater than the 60 Hz EM field intensities at both treatment sites (Equation 2) and control sites (Equation 3); and that there was no significant difference in 60 Hz EM fields between treatment and control sites (Equation 4).

Nearly all site pairs met or exceeded the EM exposure criteria. In a few exceptional cases, pairs came close, but failed to meet the criteria. Because the sites could not be relocated without also impacting matched biotic considerations, they were accepted.

At the NRTF-Republic, temporal comparisons are made between the preoperational and operational phases of the ELF Communications System in addition to the spatial comparisons of treatment and control sites. Study investigators have collected their preoperational data and are now in the operational phase of their studies. Only spatial comparisons were made at the NRTF-Clam Lake, because the transmitter has been operating since 1969 and no preoperational data base existed.

### 1.4 Annual Measurements of EM Fields

IITRI performs an annual survey to measure the EM fields at each study site. Annual measurements of 60 Hz and 76 Hz EM fields are required in order to document changes in EM exposure at study sites from year to year. Ambient 60 Hz EM fields have changed due to the construction of new power lines, variations in the local use of electric power, and the presence of the ELF antennas themselves, which have been shown to couple and reradiate 60 Hz EM fields. The 76 Hz EM field intensities produced by the ELF Communications System have changed because of reconfiguration of antenna elements and because of testing at different antenna currents. In 1989, 76 Hz EM exposures were also influenced by the *simultaneous operation of both antennas*, a system configuration not present in previous years.

Other EM aspects that have been examined during the annual surveys include 60 Hz and 76 Hz harmonics, EM field levels produced at Michigan study sites due to the operation of the NRTF-Clam Lake, and EM field values as a function of the phase angle between antennas. The former two aspects were examined and found to be below detection levels or so low that they are not considered to be a confounder in treatment-versus-control comparisons. The latter aspect--the effect of the antenna phase angle on EM exposures--was examined in Wisconsin only. This aspect is of concern for sites in close proximity to multiple antenna elements, and usually affects only the earth electric field. Phase measurements at the NRTF-Clam Lake are treated in previous annual reports.[3-7] Results showed that the effect of antenna phase angle on the longitudinal electric fields was typically less than 5%. The effect of the antenna phase angle on EM exposure is of concern at only one Michigan study site (site 10T3, bird species and communities studies). This aspect could not be measured because of schedule constraints and the full-time NRTF-Republic operating schedule, but it is expected to be similar to that in Wisconsin.

### 1.5 1990 Engineering Support

IITRI has provided a variety of engineering support in response to specific needs of individual researchers. These support activities are summarized here; details appear in Sections 2 and 4.

Special attention has been given to the characterization and reduction of ambient EM field exposure times at the laboratories of the small mammals and nesting birds and native bees studies. Laboratory EM field exposure times were initially reduced by establishing a holding facility in a low-EM field environment near the laboratories. Researchers for the small mammals and nesting birds studies began using the holding facility in 1987/88, and researchers for the native bees studies began using it in 1989/90. In 1990, before the researchers' laboratory studies were begun, efforts were made to reduce magnetic and air electric field intensities in the small mammals and nesting birds laboratory and to reduce the air electric field intensities in the native bees laboratory.

The soil amoeba studies use buried culture cells that isolate study organisms from the surrounding soil. IITRI personnel reviewed the proposed design of the culture cells in 1983, and found two areas of concern to be the matching of internal to external EM fields and the measurement of internal EM fields. IITRI subsequently designed and fabricated the culture cell exposure control apparatus to address the field-matching problem, and assisted the study investigator with field setup and installation. In 1988, IITRI fabricated and installed improved exposure control equipment and also designed and fabricated microprocessor-controlled data loggers and installed them at each study site. The data loggers make hourly measurements of the voltage and current of each culture cell, the earth electric fields at each site, and the temperatures in the partially buried data logger housings. The data logger monitoring provides documentation of any variations in either the electric fields or current densities of the culture cells that might result from factors such as rainfall, changes in temperature, or changes in the conductivity of the culture cell growth medium. In 1989, control programs for the data loggers were modified to accommodate a new operating pattern for the NRTF-Republic. Hardware modifications have also been made, including the addition of two soil temperature probes at each site in 1989 and rainfall measurement gauges in 1990. Cumulative plots of all data logger field measurements made at the soil amoeba antenna and ground study sites through 1990 are presented in this report.

The induced earth electric field is related to the frequency of the field source. This phenomenon can be predicted by field equations and has been demonstrated by field measurements. As a result of this frequency dependence, the electric fields measured by the data loggers during MSK signal operation in 1989 showed variations not present in the 1988 measurements made during CW signal operation. In 1990, a smoothing filter circuit was added to the data loggers to average out the variations inherent in the MSK signal. A similar smoothing effect was accomplished for the 1989 data by presenting daily average measurement values rather than discrete hourly data.

Researchers for the upland flora and soil microflora studies observed differences between sites in aspen growth rates. In order to test for a correlation between EM field exposures and aspen growth rates, more detailed characterization of the EM field variation across their treatment sites was needed. Measurement points were added at the antenna and ground study sites in 1989 to define EM field profiles, which could then be used to estimate EM field intensities across the study sites. In 1990, still more detailed characterization of these sites was performed by setting up a grid of electric field measurements that was used to rigorously define electric field contours at the sites. In addition, fixed earth electric field probes were established to determine temporal variations of this field at these sites. Measurements are made twice monthly at the fixed probes.

The EM treatment/control exposure ratios for two of the aquatic ecosystems study elements, insect substrates and periphyton grazing, were low in 1989, as they had been in previous ratio determinations. IITRI made suggestions for site relocations that would improve these ratios. Also in 1989, EM field

measurements were made at a 138 kV transmission line under which fish swim in movement studies. The 60 Hz EM field intensities at this location were greater than in any other part of the aquatic ecosystems study region. Recommendations were therefore made to locate an additional fyke net between the ELF antenna and the transmission line to separate the possible effects of these elevated 60 Hz fields from those of the ELF antenna. In 1990, EM field measurements were made in support of site relocation activities. A discussion of the site relocations and the resulting intersite field ratios appears in Section 2.

The bird species and communities studies use 10 census transects in the NRTF-Republic area, each of which is 200 m wide and 4.5 km long. The study investigators requested information on the variability of the EM fields along the study transects. In response, IITRI made EM field measurements at regular intervals along the five treatment transects in Michigan. The five matched control transects were not measured, because EM field variability has been shown to be markedly smaller at control sites than at treatment sites.

Temporal variations of the EM fields at study sites over the course of a year are of concern because most study biota remain on the study sites throughout the year. IITRI began to address this concern in 1988 by installing six sets of fixed earth electric field probe electrodes at the soil amoeba study sites. The data loggers used to monitor culture cell exposures at the sites are also used to measure the earth electric fields at the fixed electrodes. The earth electric field data measured at the antenna and ground study sites from 1988-1990 are presented graphically in Section 4.3.4, which also includes an analysis of earth electric field variations near an antenna ROW and a ground ROW. The ELF magnetic fields at study sites are expected to show little or no seasonal variation, because they are dependent only on fixed antenna parameters and are not affected by surrounding soil or vegetation.

In order to accommodate Navy fleet operations, the testing of new hardware, and the testing of utility interference mitigation, both the NRTF-Clam Lake and the NRTF-Republic have operated at numerous frequency, modulation, and power conditions. IITRI maintains a computer data base of operational data and provides summaries to investigators. The operational summary is intended for use by investigators, in conjunction with annually measured EM field values at the study sites, to construct EM exposure regimes.

## 2. ECOLOGICAL MONITORING STUDY SITES

Selection of treatment and control sites began in 1983 using the criteria described in Section 1.3. The sites selected for the Michigan studies are shown in Figure 3. The seven studies are identified in the upper left-hand corner of this figure. Collection sites for red maple leaves and pine needles do not appear in the figure, because they are beyond the range of the map shown.

The study sites in Michigan include treatment and control sites as well as other special sites, namely, laboratory sites, a holding facility, displacement sites, and foliage collection sites. The small mammals and nesting birds studies and the native bees studies share a holding facility that is used to house animals in a low-EM field environment near the study laboratories prior to laboratory testing. The small mammals and nesting birds studies also employ sites from which displaced animals are released. The upland flora and soil microflora studies make use of remote locations to collect foliage samples, which are brought back to the study sites. EM field exposures at all of these special sites are important because they could confound exposures at the treatment and control sites. They have, therefore, been included with treatment and control sites in the annual measurement regime for Michigan.

Because sites in Michigan were chosen prior to the completion of the NRTF-Republic antennas, their selection was based on measurements of 60 Hz EM fields and preoperational estimates of the 76 Hz EM fields that were prepared using engineering models of the proposed Michigan ELF antennas. The Michigan antennas were completed in 1986, and 76 Hz measurements were then possible for the first time. Measurements made in 1986 verified the acceptability of the Michigan treatment and control sites: all sites were confirmed to be either acceptable or conditionally acceptable, as defined in Appendix H.

The 76 Hz earth electric field ratio (R1) for several aquatic ecosystems site pairs have been low since the start of the site selection process. Nonetheless, the sites were labeled conditionally acceptable because of limitations in the length of the Ford river over which matched habitats could be found and some uncertainty of the 76 Hz field intensities under a fully operational ELF system. In 1989, EM exposure ratios were recalculated using field intensity measurement data from the fully operational ELF system. The R1 ratio continued to be of concern for all aquatic study activities. IITRI made suggestions for site relocations that would improve the intersite exposure ratios. In early 1990, IITRI personnel visited the aquatic ecosystems study sites, along with the study researchers, to discuss the site relocations, measure the EM fields at new site locations, and quantify the new EM exposure ratios.

An overview of all aquatic ecosystem study sites and activities is given in Figure 4. New site locations and several abandoned site locations are identified on this map. Site location changes and their effects on exposure ratios are discussed in the following paragraphs. Table 1 presents the R1 exposure ratios, which were recalculated using 1990 measurement data and new site locations.

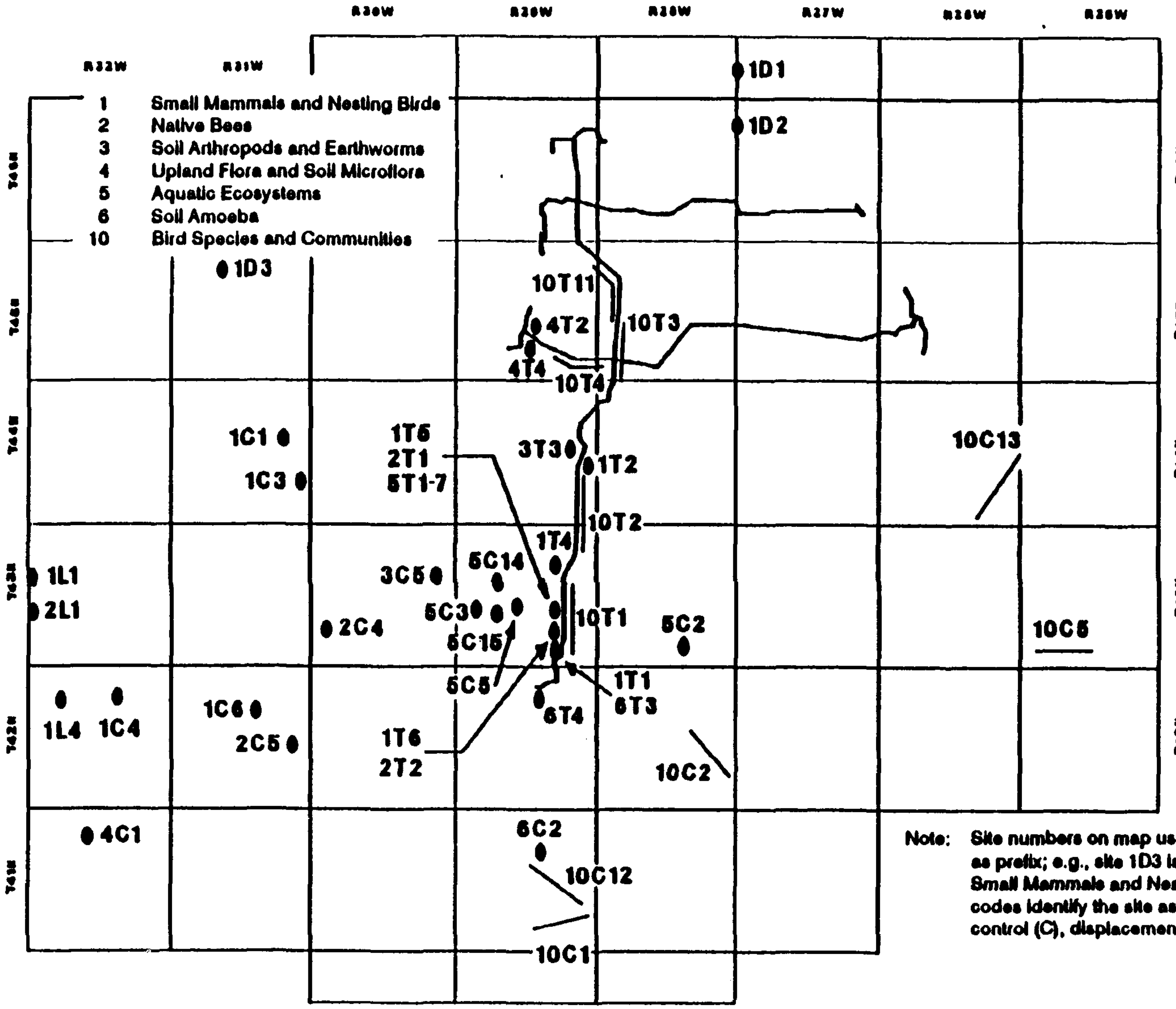



FIGURE 3. FIELD SITES FOR MICHIGAN ECOLOGY STUDIES.

Note: Site numbers on map use study number as prefix; e.g., site 1D3 is part of Study 1, Small Mammals and Nesting Birds. Letter codes identify the site as treatment (T), control (C), displacement (D), or laboratory (L).

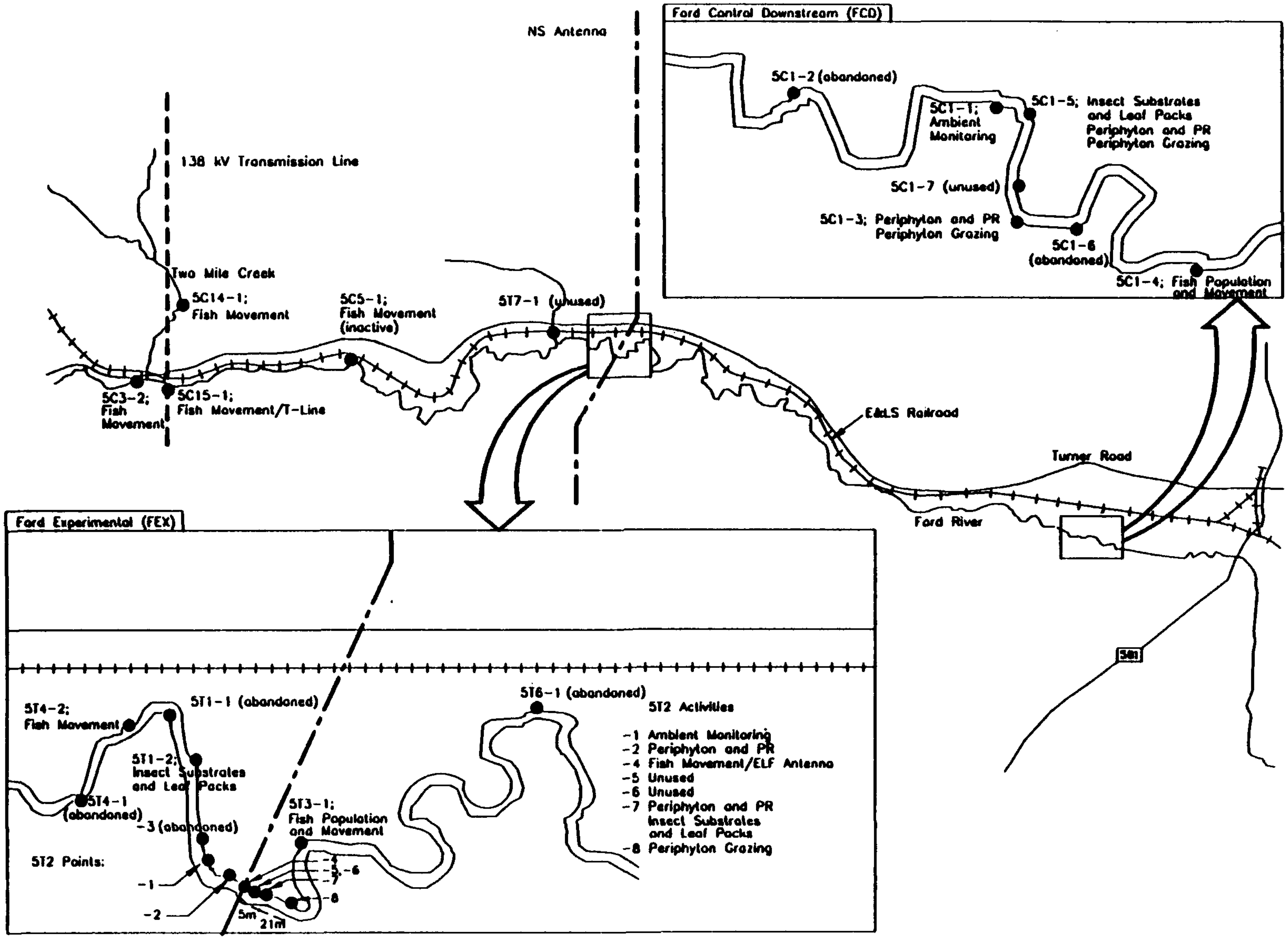



**FIGURE 4. AQUATIC ECOSYSTEMS STUDY SITE LOCATIONS.**

Increased 76 Hz EM field exposures at the treatment site were obtained by adding a periphyton and PR (photosynthesis and respiration) study location in the river segment at measurement point 5T2-7. Periphyton grazing studies remained at the 5T2-8 location. Exposure ratios were further improved for the periphyton grazing studies and the periphyton and PR studies by adding a control site study location at 5C1-3. These studies will also continue to use the previously established 5T2-2 treatment site and 5C1-5 control site locations. The new study locations give improved earth electric field R1 ratios of 10.6 and 11.9; the previous values were 5.0 and 7.7.

**TABLE 1. EM FIELD INTENSITY RATIOS**
**Aquatic Ecosystems Studies**

| Compared Sites | | R1 Ratio ($T_{(76\ Hz)}/C_{(76\ Hz)}$) | | |
|---|---|---|---|---|
| Treatment/Control | Activity | $E_A$ | $E_E$ | B |
| 5T1-2/5C1-5 | Insect Substrates and Leaf Packs | 42 | 2.6 | 66 |
| 5T2-7/5C1-5 | Insect Substrates and Leaf Packs | 6700 | 6.9 | 600 |
| 5T2-2/5C1-3 | Periphyton and PR | 270 | 7.6 | 300 |
| 5T2-2/5C1-5 | Periphyton and PR | 270 | 5.0 | 300 |
| 5T2-7/5C1-3 | Periphyton and PR | 6700 | 10.6 | 600 |
| 5T2-7/5C1-5 | Periphyton and PR | 6700 | 6.9 | 600 |
| 5T2-8/5C1-3 | Periphyton Grazing | 1080 | 11.9 | 340 |
| 5T2-8/5C1-5 | Periphyton Grazing | 1080 | 7.7 | 340 |

$E_A$ = air electric field.
$E_E$ = earth electric field.
B = magnetic flux density.

The R1 ratio for insect substrates and leaf pack studies was improved from 2.6 to 6.9 by adding a treatment site at the 5T2-7 location. Activities at the previously established 5T1-2 location are being continued for historic purposes.

In the fish movement studies, the rate of movement of fish is monitored as they swim upstream from site 5C1-4. This movement, which can be followed on the map in Figure 4, begins with the capture, tagging, and release of fish from site 5C1-4 (upper inset of figure). The fish then swim upstream to a fyke net located on the downstream side of the NS antenna at site 5T3-1 (lower inset). Times of movement to this point are recorded. The fish are then released again and continue their upstream movement. They pass beneath the NS antenna, then beneath a 138 kV transmission line, and are finally recaptured at fyke

nets at sites 5C3-2 or 5C14-1, where times of movement are again recorded. Both movement times and rates of recapture along the two stream segments are considered in the study of possible effects of EM fields on fish movement.

EM fields measured where the transmission line crosses the Ford River (5C15-1) are the largest of all 60 Hz EM fields at aquatic ecosystems study sites. The 60 Hz earth electric field under the transmission line is more than an order of magnitude less than the 76 Hz earth electric field under the ELF antenna, but the 60 Hz magnetic flux density under the transmission line is comparable to the 76 Hz magnetic flux density encountered under the antenna. This raised a concern that the 60 Hz EM fields generated by the transmission line could have an effect on fish movement. Furthermore, such an effect could mask possible effects attributable to the ELF system. Researchers addressed this concern by adding a fyke net between the NS antenna and the transmission line, approximately 50 m upstream of point 5T4-2. This additional net will isolate the stream segments in which 60 Hz and 76 Hz EM fields dominate, allowing for the study and comparison of the effects of these two EM field exposures on fish movement patterns and rates.

## 3. ANNUAL EM FIELD MEASUREMENTS

### 3.1 Description of EM Fields of Interest

The three EM fields under investigation in this program are the magnetic field, the earth electric field, and the air electric field.

A magnetic field is generated by current passing through a conductor. The ELF Communications System and power lines both produce consistent and predictable magnetic fields that are generally unaffected by the physical environment such as vegetation, soil, and nonmetallic structures. Magnetic fields are unchanged at such boundaries as air/earth or air/water. Thus, measurement techniques need not consider shielding, enhancements, or perturbations of the magnetic field from the local environment. This local uniformity of the magnetic field allows precise measurements over time, provided that the field source--in this case, the ELF antenna current--remains constant.

The electric field in the earth is measured as a difference in potential at the surface of the earth. The two sources of earth electric field associated with the ELF Communications System are (1) that induced by the magnetic field and (2) that generated by the ground terminal currents. 60 Hz earth electric fields produced by power lines are induced by the lines' magnetic fields and are also generated by unbalanced 60 Hz earth return currents associated with power distribution systems. The uniformity of earth electric fields is affected by the conductivity of soil and other factors such as large rocks, tree roots, and pools of water. Generally, the intensity of earth electric fields is fairly uniform and measurements are repeatable when anomalies are avoided. Some year-to-year variations may occur because of changes in soil moisture content, which affect soil conductivity.

The electric field in the air is generated as a result of the operating voltage or transverse potential of the ELF antenna wire with respect to ground and also as a by-product of the earth electric field. Power lines generate a transverse or vertical air electric field in a manner similar to that of the overhead antenna wire. These vertical fields are limited to the ROW and other nearby cleared areas. A difference in potential between two grounded objects such as trees is set up by the earth electric field. This difference in potential in turn generates a horizontal electric field in the air. Both the horizontal and vertical air fields are perturbed by vegetation, people, and instrumentation, all of which are more conductive than air. The perturbations of the field may take the form of an enhancing of the ambient field near objects or as a shielding effect on the surroundings. This results in a high variability of the air electric field over a small area. Efforts are made to measure the air electric field in open areas in order to determine the magnitude of the unperturbed field.

### 3.2 EM Field Probes and Measurement Equipment

The magnetic flux density, air electric field intensity, and earth electric field intensity are measured using directional field probes designed and calibrated by IITRI. Each of these probes, when placed in

the existing electric or magnetic field, outputs a voltage proportional to the field intensity. The value of the applied field can be obtained by means of individual sets of calibration factors for each probe.

The magnetic field probe is composed of a multiturned coil of wire wound on a ferrite core and shunted by appropriately chosen resistors to obtain a flat frequency response. The probe generates an output voltage that is proportional to the magnetic flux density parallel to the axis of the core. This voltage is converted to the magnetic flux density by means of a calibration factor determined prior to each field outing. Two of these probes are shown in Figure 5.

The earth electric field probe consists of three electrodes mounted on a fiberglass frame so as to form two orthogonal 1-m-spaced electrode pairs. The electrodes are pushed into the earth, and a switch connects a voltmeter across one pair of electrodes at a time. The voltage measured across each pair of electrodes is equal to the earth electric field in the given direction. This probe is shown in Figure 6. Note that a compass and a cradle are mounted atop a 1-m vertical stalk that is hinged at the juncture of the probe legs. The compass aids in alignment of the probe legs prior to raising the stalk. The cradle is designed to hold the magnetic field probe in three orthogonal positions at a 1-m height and orient the probe precisely with the legs of the earth electric field probe.

The air electric field probe consists of a spherical sensor/transmitter, a fiber-optic data link, and a receiver. The probe produces an output voltage proportional to the air electric field along the primary axis of the spherical sensor/transmitter. This voltage is converted to the electric field intensity by means of a calibration factor determined prior to each field outing. The calibration factor and probe operation are checked periodically using a portable electric field probe calibrator. This probe is shown in Figure 7. In very cold weather, a styrofoam-and-plastic shell is placed over the probe during measurements for protection and insulation.

IITRI has developed a computer-driven system for calibrating electric and magnetic field probes over their usable frequency range (see Figure 8). At the heart of the system are:

- a Hewlett-Packard 868 computer equipped with an IEEE 488 instrument interface bus
- a Hewlett-Packard 3421A data acquisition unit
- a Valhalla 2703 precision ac calibrator

The calibration system generates a uniform electric field between a pair of 1-m-square, 1/3-m-spaced parallel plates with guard rings. A uniform magnetic field is generated over a large volume by a set of 1-m-radius Helmholtz coils.

The calibration system produces a table of each probe's calibration factors and a plot of the probe's transfer function versus frequency. The magnetic field probe and air electric field probe are calibrated before and after each use, and a record is kept of all calibrations.

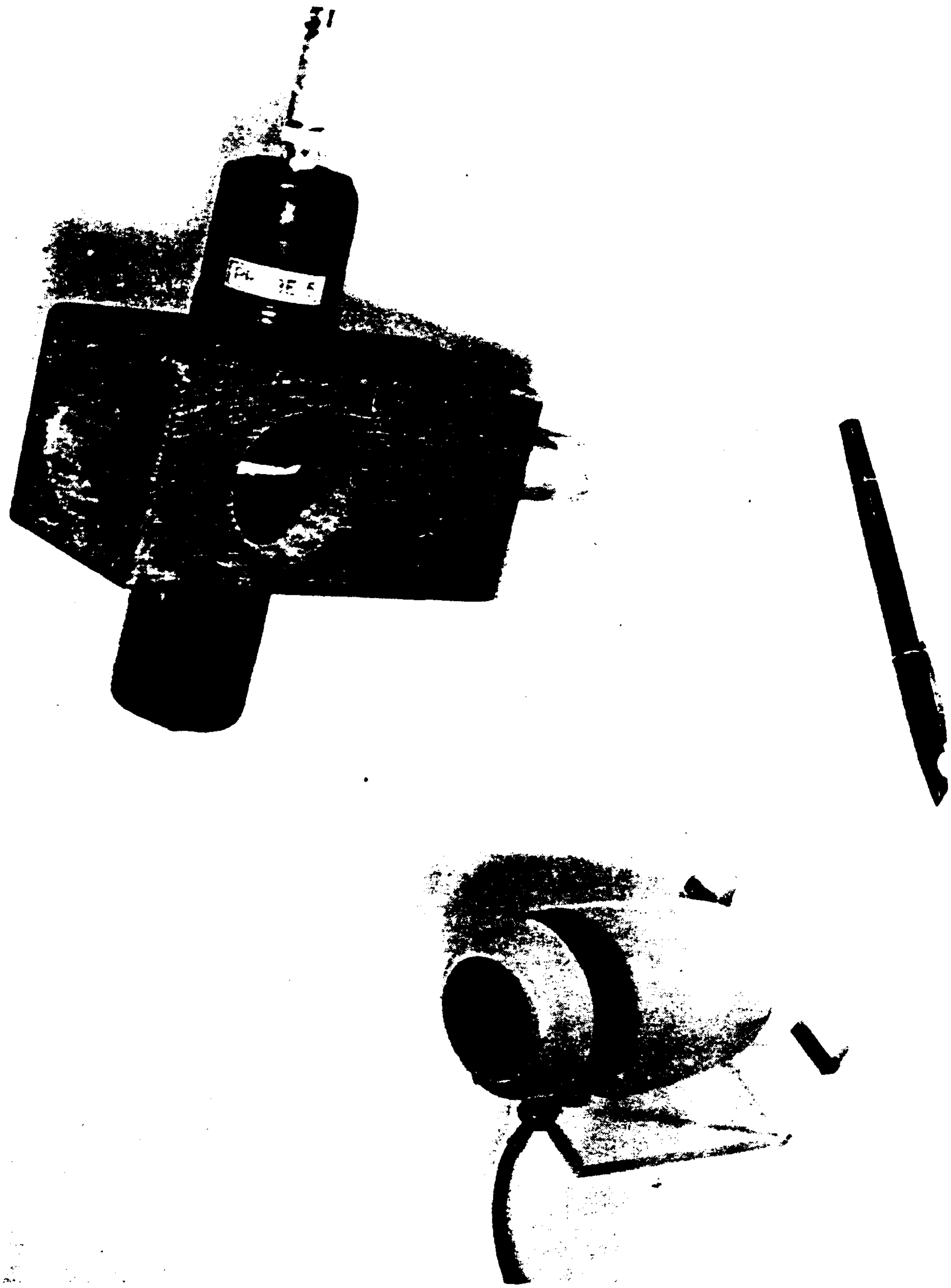


FIGURE 5. MAGNETIC FIELD PROBES.

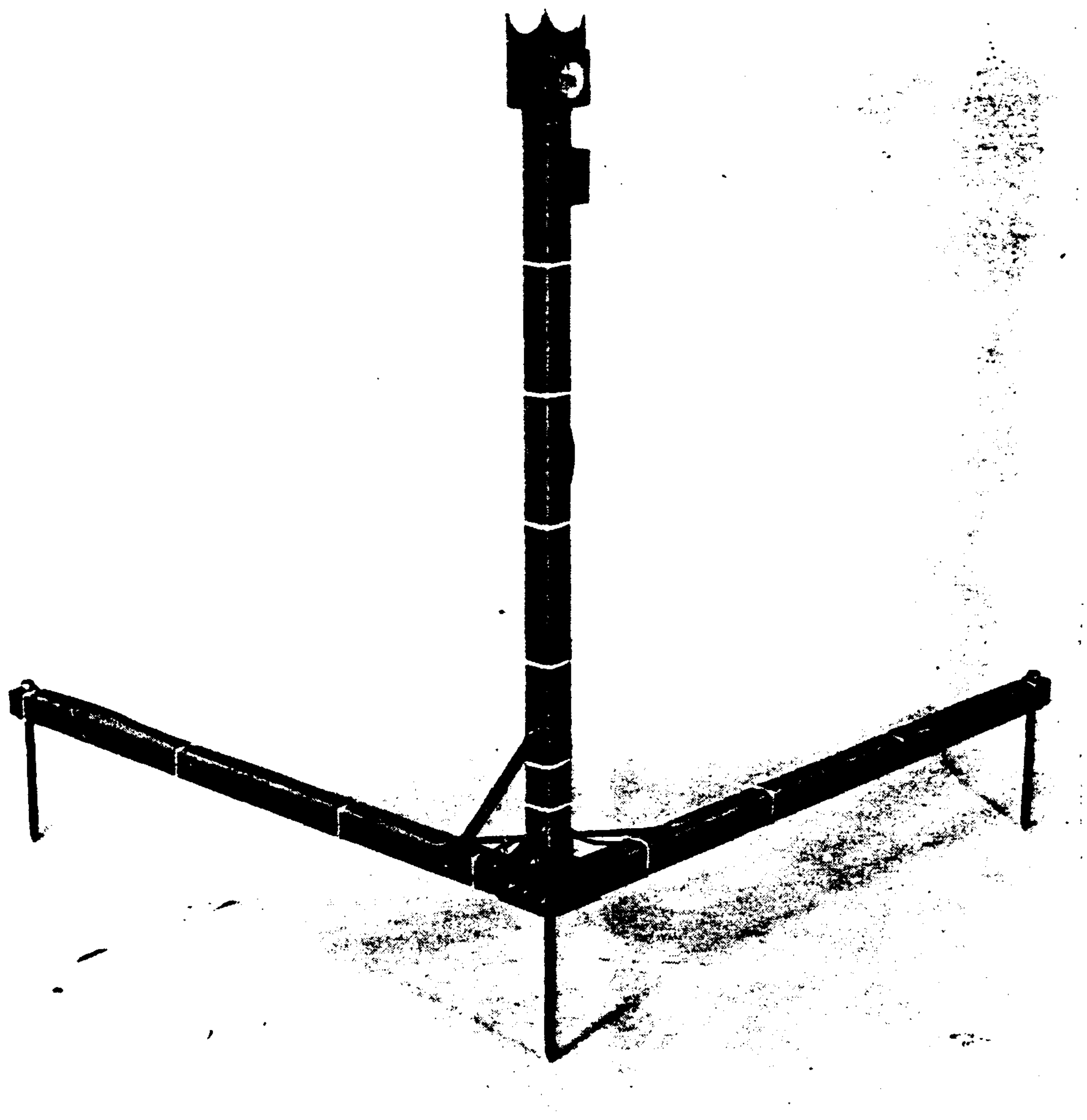


FIGURE 6. EARTH ELECTRIC FIELD PROBE.

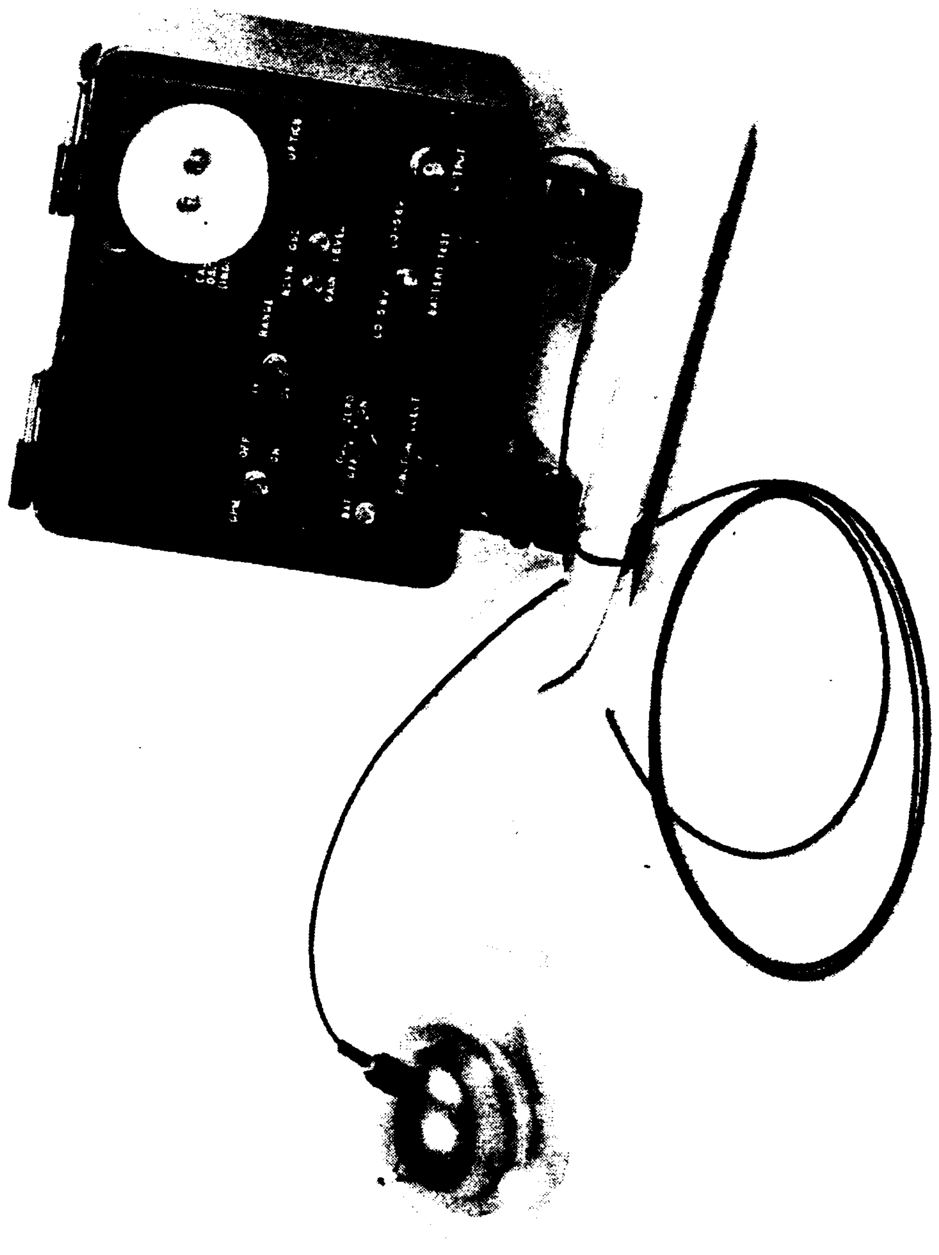


FIGURE 7. AIR ELECTRIC FIELD PROBE.

FIGURE 8. COMPUTER-DRIVEN ELECTRIC AND MAGNETIC FIELD PROBE CALIBRATION SYSTEM.

The magnetic field probe calibration fluctuates by no more than ±1% over a one-year period. This probe is constructed entirely of passive components, making routine calibration checks during field measurements unnecessary. The earth electric field probe, which consists solely of a perpendicular pair of 1-m-spaced electrodes, requires no calibration, and its mechanical stability is excellent. The air electric field probe calibration fluctuates by no more than ±5% over a one-year period. There is little difference in the calibration of this probe with or without its insulating styrofoam-and-plastic shell. Portable electric field calibration plates are used during field measurements so that probe operation can be verified periodically.

The meter used to measure the output voltages of the probes is a Hewlett-Packard 3581A signal wave analyzer. The HP 3581A functions as a frequency selective, rms-calibrated voltmeter with factory modifications for battery and 1 Hz bandwidth operation. A 3 Hz bandwidth is used to measure 60 Hz and unmodulated ELF signals, but a wider bandwidth is needed to measure modulated ELF signals. Because the wider bandwidth will include 60 Hz signals produced by power lines, an IITRI-fabricated active notch filter is placed in series with the wave analyzer when the 60 Hz and ELF signals are of similar magnitudes in order to remove the 60 Hz signals and their harmonics.

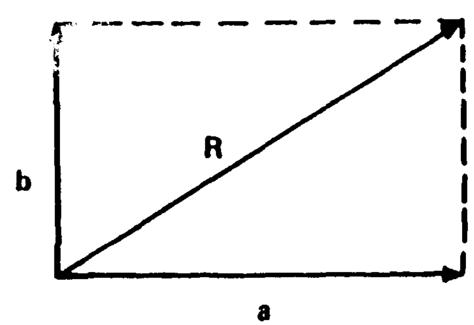
## 3.3 EM Field Measurement Techniques and Protocols

### 3.3.1 Determining EM Field Magnitudes

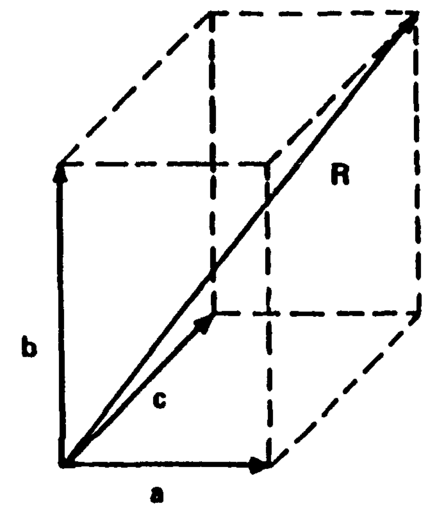
The magnitude of an EM field vector is determined by measuring its orthogonal components. This requires measurements with the field probe oriented along three orthogonal axes. For simplicity and repeatability, the axes chosen are aligned in the north-south, the east-west, and the vertical directions. The earth electric field intensity has no vertical component; therefore, only the north-south and east-west components are measured. In the case of the air electric field and magnetic flux density, all three orthogonal field components are measured. The orthogonal measurements are then used to compute a vector sum or maximum.

A geometric presentation of the measurement and summation of orthogonal components is shown in Figure 9. The figure presents the two-dimensional earth electric field geometry and the three-dimensional magnetic field and air electric field geometry. The resultant, R, in each case is the vector sum of the individual orthogonal components and is the value reported in data tables.

One disadvantage of the orthogonal components method is that it yields the correct field maximum only when a single field source is present or is dominant. Fortunately, this is generally the case. When more than one field source is present, the computed vector sum will be conservative; that is, it will be greater than or equal to the actual maximum. Measurements have been made in Wisconsin at those sites where a single antenna does not dominate, and site-specific correction factors (typically less than




$$R = \sqrt{a^2 + b^2}$$




$$R = \sqrt{a^2 + b^2 + c^2}$$

FIGURE 9. GEOMETRIC PRESENTATION OF THE VECTOR SUM OF ORTHOGONAL MEASUREMENT COMPONENTS.

5%) were determined for calculating actual field magnitudes. Similar measurements have not been possible in Michigan.

### 3.3.2 Measurement Conditions--Michigan

Construction of the NRTF-Republic began in 1984 and continued through 1985. During this period, the NRTF-Republic was not capable of generating ELF EM fields. Construction of the NRTF-Republic was completed in early 1986, and intermittent operation began with low power levels of 4 to 10 amperes of antenna current. Only one antenna or antenna element (the NS antenna or the NEW or SEW antenna element) was operated at any one time during 1986. From 1987 onward the NEW and SEW antenna elements were connected in parallel and operated as one antenna, hereafter referred to as the EW antenna. The NRTF-Republic operated intermittently with a 15 ampere antenna current in 1987, increasing to 75 ampere antenna currents during 1988 and early 1989. During 15- and 75-ampere operation, only one antenna was operated at any one time. From May 1989 onward, the NRTF-Republic operated both antennas (NS and EW) simultaneously, at a full-power current level of 150 amperes. Both modulated and unmodulated (continuous wave) signals were employed.

Table 2 summarizes the predominant operating conditions under which measurements have been made in Michigan. In all cases, the orthogonal components of the magnetic flux density and of the transverse and longitudinal electric fields were measured, and a vector sum magnitude was computed for each EM field. Unless otherwise stated, this vector sum magnitude is the value reported in all measurement documentation.

**TABLE 2. ANTENNA OPERATING CONDITIONS DURING 76 Hz EM FIELD MEASUREMENTS IN MICHIGAN**

| Antenna Condition | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|
| Antenna or Antenna Element | NS<br>NEW<br>SEW | NS<br>EW | NS<br>EW | B* | B* |
| Antenna Current (amperes) | NS--4<br>NEW--6<br>SEW--6 | NS--15<br>EW--15 | NS--75<br>EW--75 | NS--150<br>EW--150 | NS--150<br>EW--150 |
| Frequency (Hz) | 76 | 76 | 76 | 76 | 76 |
| Modulation | CW | CW | CW | CW, MSK | MSK |
| Phase | N/A | N/A | N/A | 86° | 86° |
| Status of Non-Driven Antenna Element(s) at Transmitter | Grounded | Connected to transmitter | Connected to transmitter | N/A | N/A |

*Both = Both antennas simultaneously.

The following subsections describe the 1986-1990 measurement protocols used in Michigan.

**3.3.2.1 1986 Conditions.** The 1986 EM measurement protocol for Michigan was as follows:

- Ambient 60 Hz EM fields were measured with the NS antenna and both EW antenna elements off.
- 76 Hz EM fields from the NS antenna were measured with both EW antenna elements off.
- 76 Hz EM fields from the NEW antenna element were measured with the NS antenna and the SEW antenna element off.
- 76 Hz EM fields from the SEW antenna element were measured with the NS antenna and the NEW antenna element off.

All measurements were made using a meter bandwidth setting of 3 Hz to discriminate the frequency of interest.

**3.3.2.2 1987, 1988 Conditions.** In 1987 and 1988, the EM measurement protocol for Michigan changed from the 1986 protocol to account for the new EW antenna configuration. That revised protocol was as follows:

- Ambient 60 Hz EM fields were measured with both antennas off.
- 76 Hz EM fields from the NS antenna were measured with the EW antenna off.
- 76 Hz EM fields from the EW antenna were measured with the NS antenna off.

All measurements were made using a meter bandwidth setting of 3 Hz to discriminate the frequency of interest.

**3.3.2.3 1989, 1990 Conditions.** In 1989 and 1990, the EM measurement protocol for Michigan changed again because of simultaneous operation of the NS and EW antennas during all measurements. Modulated signal operation also necessitated protocol modifications. The 1989 and 1990 protocol was as follows:

- Ambient 60 Hz EM fields at control study sites were measured under any antenna operating conditions.
- Ambient 60 Hz EM fields at treatment study sites were measured either with the antennas off or operating with an unmodulated signal. Measurements of 60 Hz fields at treatment sites could not be made under modulated signal operation.
- 76 Hz ELF EM fields were measured with both antennas on and with either a modulated or unmodulated signal.

Unmodulated ELF and 60 Hz EM field measurements were taken using a meter bandwidth setting of either 1 Hz or 3 Hz to discriminate the frequency of interest. Modulated ELF signals were measured using a meter bandwidth setting of 30 Hz. A 60 Hz notch filter was employed at some control sites to allow measurement of modulated ELF signals.

### 3.3.3 Selection of Measurement Points

Measurement points at study sites were selected to define the spatial variation of the 76 Hz EM fields over each site. This was done on the basis of the size and shape of a site and its location relative to the antenna elements, as described below.

Control sites, all of which are several miles from the nearest antenna element, are expected to have minimal EM field gradients. At small control sites, a single measurement point was deemed sufficient to characterize the EM fields. Intermediate-size control sites were measured at the points nearest to and farthest from the antenna grid. Large control sites were measured at several more points in order to accurately define the EM field gradients across them.

EM field gradients across treatment sites are larger than gradients at control sites. It was generally necessary to make multiple measurements at all treatment sites. The selection of measurement points for the treatment sites was based on one of four strategies dictated by the nature of the site. For sites comprised of long, narrow transects parallel to the antenna (e.g., the bird species and communities studies), measurements typically were taken at the ends of the transect and often at intermediate points along the transect. For sites of very restricted area (e.g., the aquatic ecosystems studies), only one measurement was made at each experiment location. Two other measurement strategies were applied at treatment sites covering a large area. For those sites arranged with well defined, grid-like borders, measurements were made at the borders or corners of the plots such that the measurements encompassed the study area and bounded the field levels. For those sites with irregular borders, such as those for the nesting birds study, measurements were made along a transect perpendicular to the antenna, typically at 25-m intervals, to provide a profile of the field gradients.

These measurement point selection techniques allow the investigators to estimate the EM field intensity at any point of interest within a study plot. Such estimates can be made based on the fact that the EM fields vary greatly with distance from the antenna but show little variation along a path parallel to it. Therefore, given the distance of a point of interest from the antenna, the EM fields can be estimated by linear interpolation between measured values at greater and lesser distances from the antenna. Because the EM fields vary little along a path parallel to the antenna, the point of interest and measured points do not need to be at the same lateral position along the length of the antenna. The accuracy of field estimations for any point can be improved by plotting the EM field gradients as a function of distance from the antenna and using graphical rather than linear interpolation between measured points. This technique can be applied to the field profiles for the nesting birds study sites and the upland flora and soil microflora study sites, which appear in Appendixes A and D.

### 3.4 Summary of 1990 Measurement Data

Measurements in Michigan were conducted on 9, 10, and 22 January, 8, 9, and 11 May, 27-30 June, 19 August, and during the weeks of 24-28 September and 2-12 October 1990. All active sites were measured during these periods.

Table 3 presents a summary of the number of sites and measurement points examined during 1990. As shown, a total of 202 measurement points were needed to characterize 50 sites. The number of measurement locations per site was determined by plot size, the presence of known or anticipated EM field gradients, and the information needed by the study investigators for statistical analyses.

**TABLE 3. SUMMARY OF 1990 EM FIELD MEASUREMENTS**

| | Number of Measurement Sites | | | Number of Measurement Points | | |
|---|---|---|---|---|---|---|
| Study | Pre-Existing, Still in Use | New, 1990 | Total | Pre-Existing, Still in Use | New, 1990 | Total |
| Small Mammals and Nesting Birds | 14 | 0 | 14 | 70 | 1 | 71 |
| Native Bees | 6 | 0 | 6 | 18 | 3 | 21 |
| Soil Arthropods and Earthworms | 2 | 0 | 2 | 8 | 0 | 8 |
| Upland Flora and Soil Microflora | 6 | 0 | 6 | 45 | 5 | 50 |
| Aquatic Ecosystems | 9 | 0 | 9 | 13 | 6 | 19 |
| Soil Amoebae | 3 | 0 | 3 | 9 | 0 | 9 |
| Bird Species and Communities Michigan | 10 | 0 | 10 | 24 | 0 | 24 |
| **Total** | **50** | **0** | **50** | **187** | **15** | **202** |

#### 3.4.1 Michigan Measurement Data

The data taken during the 1990 EM measurements in Michigan appear in Appendixes A through G. There are six data tables in each of these appendixes that document 60 Hz and 76 Hz measurements of the air electric field, earth electric field, and magnetic flux density taken at historic points. In addition, separate tables document measurements taken at the small mammals and nesting birds and native bees laboratories, at fixed probes for the upland flora and soil microflora studies, at soil amoeba culture cells by data loggers, and at regular intervals along treatment transects of the bird species and communities studies. Details of these measurement activities are discussed in Section 4.

In each appendix, the tables of 60 Hz data appear first. Each table contains a separate column of data for each year from 1983 through 1990. A footnote for each column describes the physical status of the ELF antenna during the 60 Hz measurements for that year. The physical status of the ELF antenna has a significant impact on the 60 Hz EM fields measured at treatment sites, because it affects the degree of coupling to the antenna of 60 Hz EM fields generated by nearby power lines. This phenomenon is explained in Section 3.4.2.

Following the 60 Hz data tables are tables containing 76 Hz EM field intensities measured in 1986 through 1990. The 76 Hz EM field intensity data were taken at several different antenna operating currents, ranging from 4 amperes in 1986 to the full operating power of 150 amperes in 1989. Specific operating currents are given in the column headings of the data tables. EM field intensity values, as shown in the data tables, have increased in proportion to the antenna operating current from 1986 through 1990.

### 3.4.2 Coupling of 60 Hz Fields

The 60 Hz data for Michigan studies in Appendixes A through G show that there were significant yearly fluctuations of the 60 Hz EM fields from 1983 through 1990. The primary factors in these fluctuations were:

- completion of antenna installations in 1986
- parallel connection of the two EW antenna elements in 1987
- differences in antenna-to-power amplifier connections in the antenna "off" mode
- changes in power line loads
- changes in earth conductivity

The first three factors apply only to treatment sites; the last two apply to both treatment and control sites.

The 60 Hz EM fields at the treatment sites are strongly influenced by the presence of the ELF antenna elements. This is because EM fields generated by 60 Hz power lines couple to the conducting loop formed by the ELF antenna, its ground terminals, and the earth. This coupling results in a 60 Hz current flow on the antenna wires that in turn sets up new 60 Hz EM fields nearby. The 60 Hz EM fields generated by the two sources (power lines and antenna) interact at treatment study sites and elsewhere. The general observation has been that the longitudinal electric fields sourced by the power lines and antenna partially cancel each other. The relative magnitude of the resulting EM field is dependent on the intensities of the EM fields generated by the two sources. The magnetic fields from power lines fall off more rapidly than the longitudinal electric fields, and they do not appear to significantly interact with the 60 Hz magnetic fields from the antenna. The result is that 60 Hz magnetic fields near the antenna are greater in magnitude than those measured prior to antenna construction.

The coupling of ambient 60 Hz fields to the ELF antenna was first observed in 1986, coincident with the completion of antenna construction in Michigan. This coupling will continue as long as the ELF antenna and power lines are present. Year-to-year differences in the treatment site 60 Hz EM fields are likely due to changes in coupling to the antenna elements resulting from changes in antenna configuration and to changes in 60 Hz power line loads. The antenna configuration changes have been the connection of the two EW antenna elements in parallel beginning in 1987 and differences in the antenna connections to the power amplifiers in the antenna "off" mode--the antenna condition under which most 60 Hz measurements are made.

In 1988, 60 Hz coupling to the NS antenna appeared to have increased substantially. This correlates with large load increases on a transmission line that parallels the NS antenna element about four miles to the west. The purchase of the Presque Isle power plant by Wisconsin Electric Power Company in January 1988 and its subsequent operation as a major producer of electrical energy in the region suggests that this line will remain heavily loaded.

Variations in the 60 Hz EM fields at control sites are not related to the location of the ELF antenna or its configuration. Variations here are most likely the result of varying power line currents and temporal changes in earth conductivity. These same factors also influence the 60 Hz EM fields at treatment sites, but not necessarily to the same extent.

# 4. ENGINEERING SUPPORT ACTIVITIES

## 4.1 Laboratory Measurements

Some study species are subjected to EM exposures other than those at the established study sites. The experimental protocols for the studies of small mammals and nesting birds and of native bees, for example, are unique in that they require the study species to be removed from the study sites to undergo laboratory measurements, after which they are returned to the study sites. The EM environment at these laboratories should match the criteria established for control sites such that possible differences between treatment and control animals attributable to 76 Hz EM field exposure are not masked by unwanted EM field exposures at the laboratories.

Measurements made at the laboratories of the small mammals and nesting birds and the native bees studies in past years showed that the 60 Hz EM fields there were on the same order of magnitude as 76 Hz EM fields at the test sites. Efforts were made to reduce these exposures (1) by asking investigators to limit the amount of time study biota spend at the laboratory, and (2) by reducing the EM field intensities at the laboratory. A discussion of these efforts follows.

### 4.1.1 Small Mammals and Nesting Birds Laboratory Measurements

It is not known *if* ELF EM fields affect vertebrate metabolism, nor which aspects of exposure (i.e., intensity, duration, or both) could be important. The unmitigated 60 Hz EM field intensities at the small mammals and nesting birds laboratory in Crystal Falls are high relative to both 76 Hz and 60 Hz EM intensities at the study sites. Nevertheless, there exists a need to move animals from study sites to the laboratory for testing. The 60 Hz fields at the laboratory are considered as possible contaminants, and measures that reduce both the duration and intensity of exposure of the study animals to 60 Hz EM fields at the laboratory have been recommended and implemented.

In order to reduce the amount of time that animals spend at the laboratory site to a few hours or less, a remote holding facility was set up in 1987/88 for the animals to reside in prior to laboratory testing. A holding facility is required because the tests are conducted in winter, and daily access to the study sites would be extremely difficult and time-consuming. The EM field values at the remote holding facility are similar to those at the control sites.

The 60 Hz magnetic and air electric field values measured in the laboratory in early 1989 were nominally on the same order of magnitude as the 76 Hz field values at the treatment sites during full-power operation of the NRTF-Republic. Prior to 1990 metabolic studies, IITRI acted to reduce the laboratory magnetic fields at the cooling bath, where they were the highest, by designing, fabricating, and installing magnetic shielding for the cans used to hold animals in the bath during metabolic testing and for the motors contained in the bath. IITRI also performed mitigation tests and recommended methods of lowering the air electric fields throughout the laboratory.

The approach taken for magnetic shielding was to use a metal with high magnetic permeability to redirect or "duct" magnetic flux away from the cans. Thin (0.025 in.) magnetic shield material was wrapped snugly around the sides of each can, and discs of the same material were attached to the top and bottom. In order to maintain the thermal transfer properties of the cans, an alumina-impregnated material (0.065 in. uncompressed) was sandwiched between the magnetic shielding and the steel cans. This heat-transfer material filled the air gap between the shield and the cans, which otherwise might function as a thermal insulator. A shielded can was only slightly larger than its unshielded counterpart, and only minor changes were necessary in the fixtures used to position the cans in the bath.

The principal sources of the magnetic fields in the bath were a pump motor and a compressor motor. Magnetic fields from these sources were redirected using three magnetic shields. Figure A-40 (see Appendix A) shows the cans in the cooling bath with all magnetic shields in place.

Motor and can shields together reduced the magnetic field exposures inside the cans by 30 to 68 times at the two locations used for testing, thus lowering the magnetic flux densities to 0.077 mG and 0.081 mG. These reduced 60 Hz magnetic fields are 20 to 500 times lower than 76 Hz magnetic fields and roughly equivalent to 60 Hz magnetic fields at treatment sites.

The air electric field intensities in the laboratory were reduced by shielding and/or grounding identified field sources. Field mitigation techniques recommended by IITRI were as follows:

- Overhead fluorescent light fixtures should be put on a grounded circuit with wiring in metal conduit.
- The fluorescent tubes should be shielded with 0.25-in.-mesh hardware cloth, grounded to the light fixture.
- The desk lamp bulb should be shielded with 0.25-in.-mesh hardware cloth, grounded to the lamp frame.
- Large metallic objects (desks and locker) in the laboratory that have a non-zero potential, and hence set up an air electric field, should be grounded.
- A 0.25-in.-mesh hardware cloth shield should be installed beneath and behind the animal holding cages in the laboratory and grounded. Clip leads should be installed to directly ground the animal cage assemblies.
- A ground rod and clip leads to ground the animal cages located at the short-term holding area on the side of the shed outside the laboratory should be installed.

These recommendations were implemented by the study investigators and had the effect of reducing the laboratory air electric fields by 4.5 to 20 times. The 60 Hz air electric fields in the laboratory are now on the same order of magnitude as the 76 Hz air electric fields and 1 to 500 times higher than the 60 Hz electric fields at treatment sites. Measurements made at the small mammals and nesting birds laboratory are detailed in Appendix A.

### 4.1.2 Native Bees Laboratory Measurements

Measurements of EM fields at the native bees laboratory in Crystal Falls, first made in 1988, showed that the 60 Hz fields in the laboratory were up to 1000 times the value of 60 Hz fields at the study sites, and equal to or greater than the 76 Hz exposures at the study sites. IITRI recommended that these exposures be reduced by limiting the amount of time that the bee nest blocks are kept at the laboratory. This was accomplished by holding the bees, prior to laboratory testing, in the remote holding facility used by the small mammals and nesting birds investigators. As a further step, EM field exposures were reduced by moving the laboratory testing location from the basement of the laboratory to the second floor, where EM field intensities are lower.

EM field intensities were remeasured in the laboratory in 1989. The 60 Hz air electric fields in the second-floor testing area and on the porch, where nest blocks are held prior to examination, were still high relative to the EM field exposures at the study sites. In fact, they were roughly 50 times greater than the 76 Hz transverse electric field intensities near the bee hutches at the treatment study sites during full-power operation of the antennas.

Prior to 1990 laboratory testing, IITRI fabricated wire-mesh Faraday cages to shield these areas from the 60 Hz air electric fields. Measurements showed the cages to be effective in reducing the 60 Hz air electric field levels to less than the 76 Hz air electric field levels at treatment study sites. The shielding effectiveness of the cages is dependent on several factors, as can be seen in Table B-9 (see Appendix B), which gives measurement results for different setups. The shielding is most effective with the hatch doors closed and no worker present, as expected. Opening the hatch doors increases the field levels by at least a factor of 20. The presence of a worker not grounded to the cage raises the field levels close to those measured in the absence of a cage. This is because of a potential difference between the body of a worker and the cage. By grounding the body of the worker to the cage by means of a wrist strap, this potential difference is eliminated and fields are reduced by about a factor of 100, i.e., to less than five times the field levels measured with hatch doors closed. Based on these measurements, IITRI made the following operating recommendations for use with the Faraday cages:

- Hatch doors should be kept closed when nest boxes are present but work is not being performed.
- When work is in progress, only those hatches needed should be open, and the worker's body should be grounded to the cage by means of the wrist strap and clip lead provided.
- The situations of an ungrounded worker, or of an open hatch in the absence of a worker, should be avoided.

Special consideration was given to the type and mounting of the lamps used with the cages. The lamps chosen have all-plastic cases for electrical safety and are clipped to a wooden mounting strip on

the top of the cages for additional electrical isolation from the mesh. IITRI recommended that metal lamps never be rested on the cages.

The 60 Hz magnetic flux densities measured at the laboratory in 1990 (Table B-10) were similar to those measured in 1989. They were typically at least a factor of 10 lower than the 76 Hz magnetic flux densities measured at the treatment sites during full-power antenna operation. Shielding of the magnetic fields is not being considered for this laboratory.

## 4.2 Spatial EM Field Variability

### 4.2.1 Bird Species and Communities Studies

The bird species and communities studies monitor migrating bird population using a census technique involving study transects that are 200 m wide by 4.5 km long. Ten such transects (five treatment and five control) are located near the NRTF-Republic. Each is divided into eight sub-transects of 500 m with 50-m buffers between the sub-transects.

Historically, EM field measurements have been made along each transect center line at its start and end, and in some cases, at intermediate points as well. In 1990, EM field variations along the treatment transects were more thoroughly characterized by measuring the earth electric field and the magnetic flux density at the start and end, and at each "X" flag between sub-transects. The measurement results, tabulated in Table G-9 (see Appendix G) and plotted in Figures 10-14, show the variations of the fields along the transects.

With constant antenna current, the magnetic flux density is dependent only on the distance of a measurement point from the antenna. The variability of the magnetic flux density along the treatment transects is generally very small, indicating that the transects are at a relatively constant distance from the antennas. There are two exceptions to this, at points on the Schwartz Creek and Flat Rock Creek transects. On the Schwartz Creek transect, the magnetic flux density is about twice its average value between sub-transects C and D, where the separation between the transect and the antenna ROW was visually observed to be less than the standard 125 m. On the Flat Rock Creek transect, which parallels the NS antenna, the magnetic flux density increases greatly at the start of the G sub-transect because the southern EW antenna element crosses the transect at this point.

It is evident from Figures 10-14 that the 76 Hz earth electric field intensities are considerably more variable along the treatment transects than are the corresponding magnetic flux densities. This additional variation is related to local soil conductivity, which varies with factors such as soil type, the presence of large rocks or tree roots, and soil moisture content.

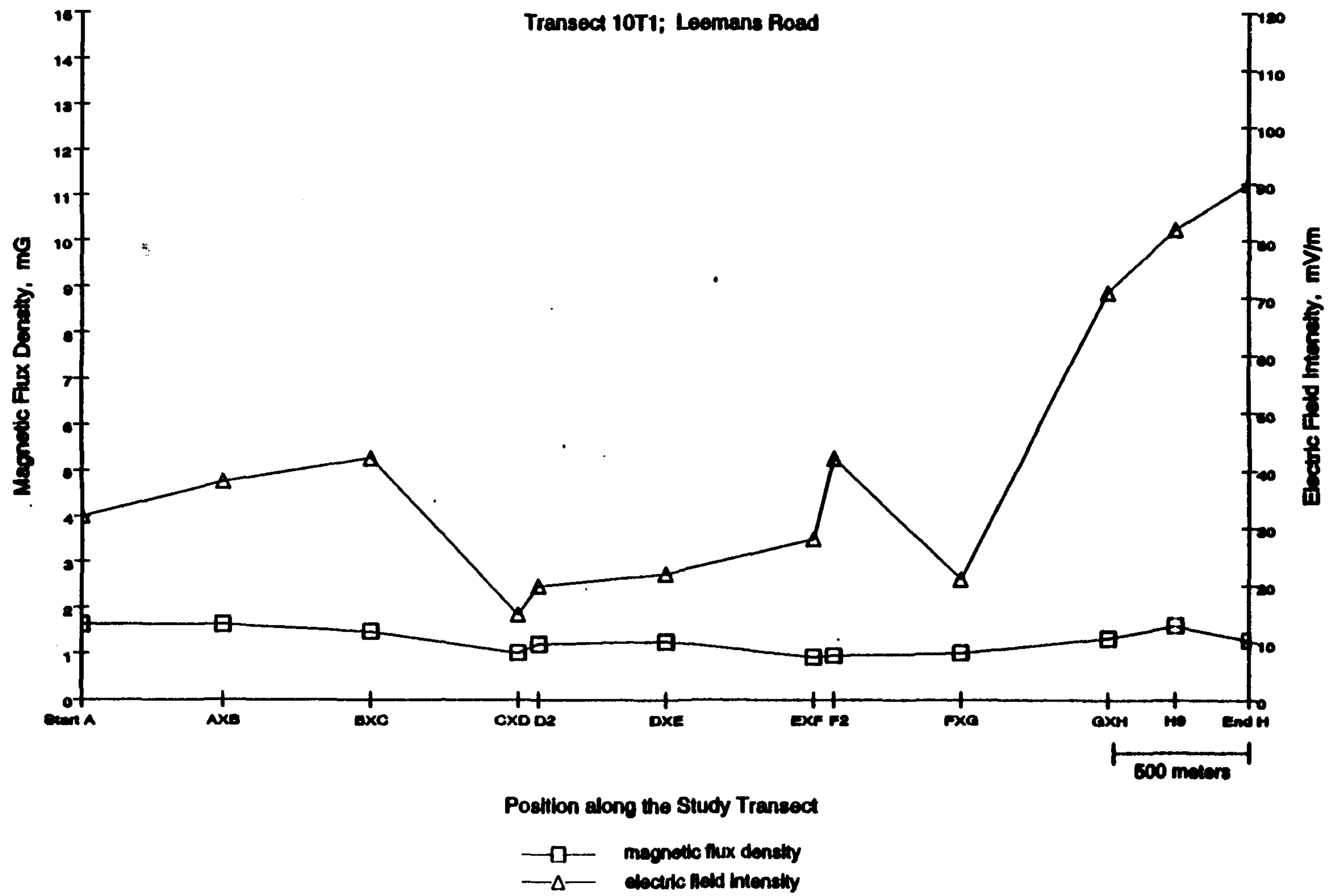



FIGURE 10. EM FIELD VARIATIONS ALONG STUDY TRANSECT 10T1.

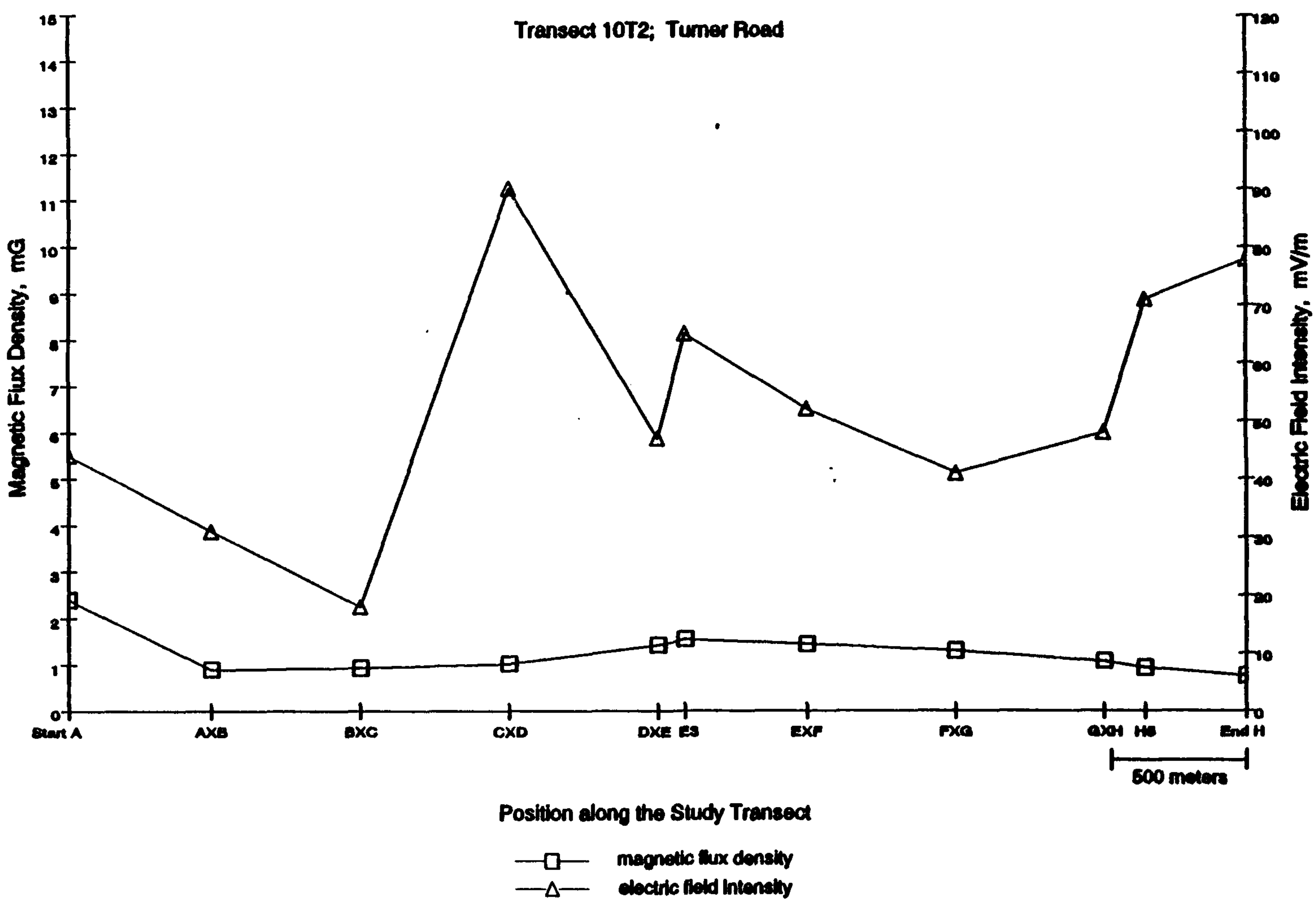



**FIGURE 11. EM FIELD VARIATIONS ALONG STUDY TRANSECT 10T2.**

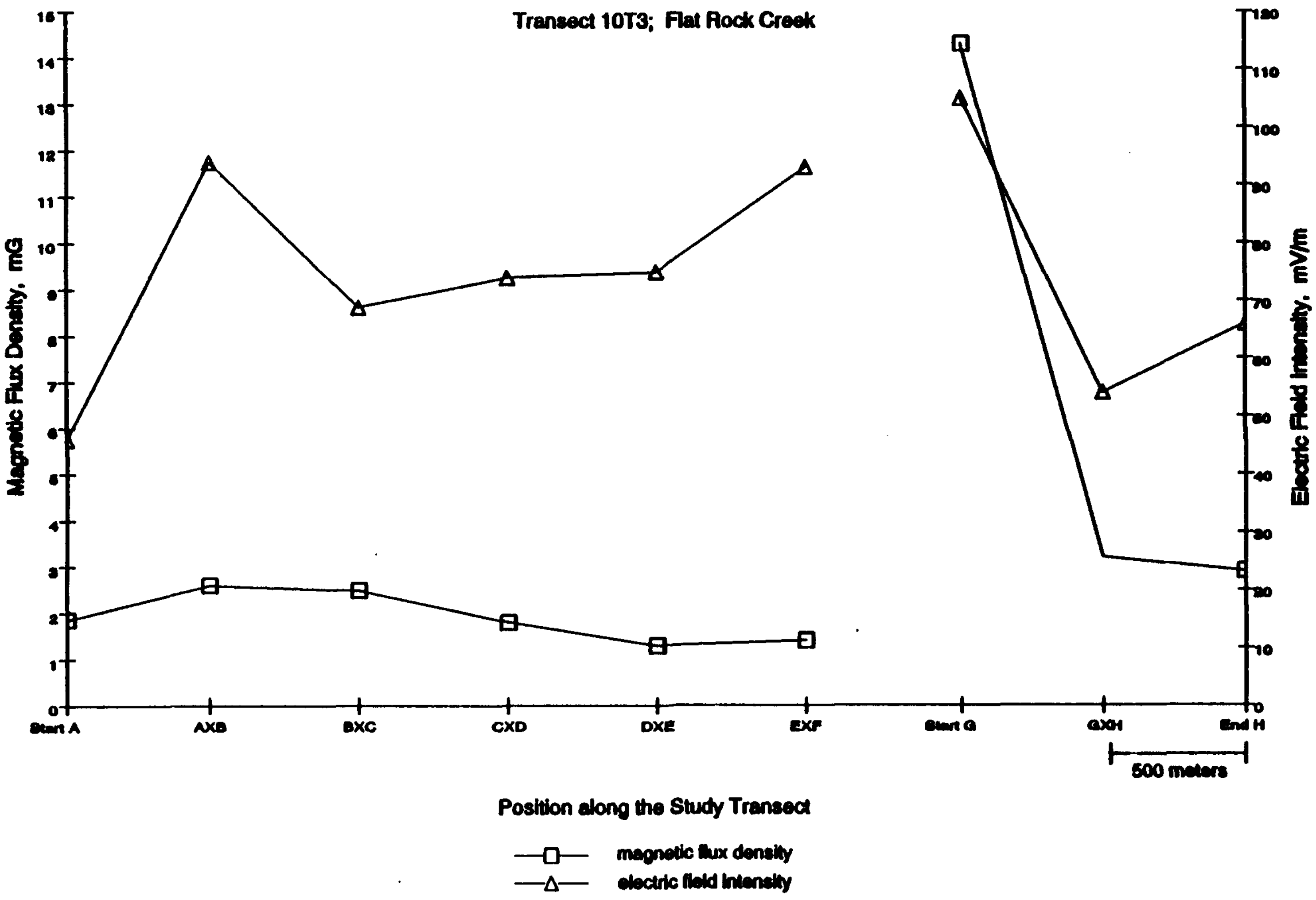



FIGURE 12. EM FIELD VARIATIONS ALONG STUDY TRANSECT 10T3.

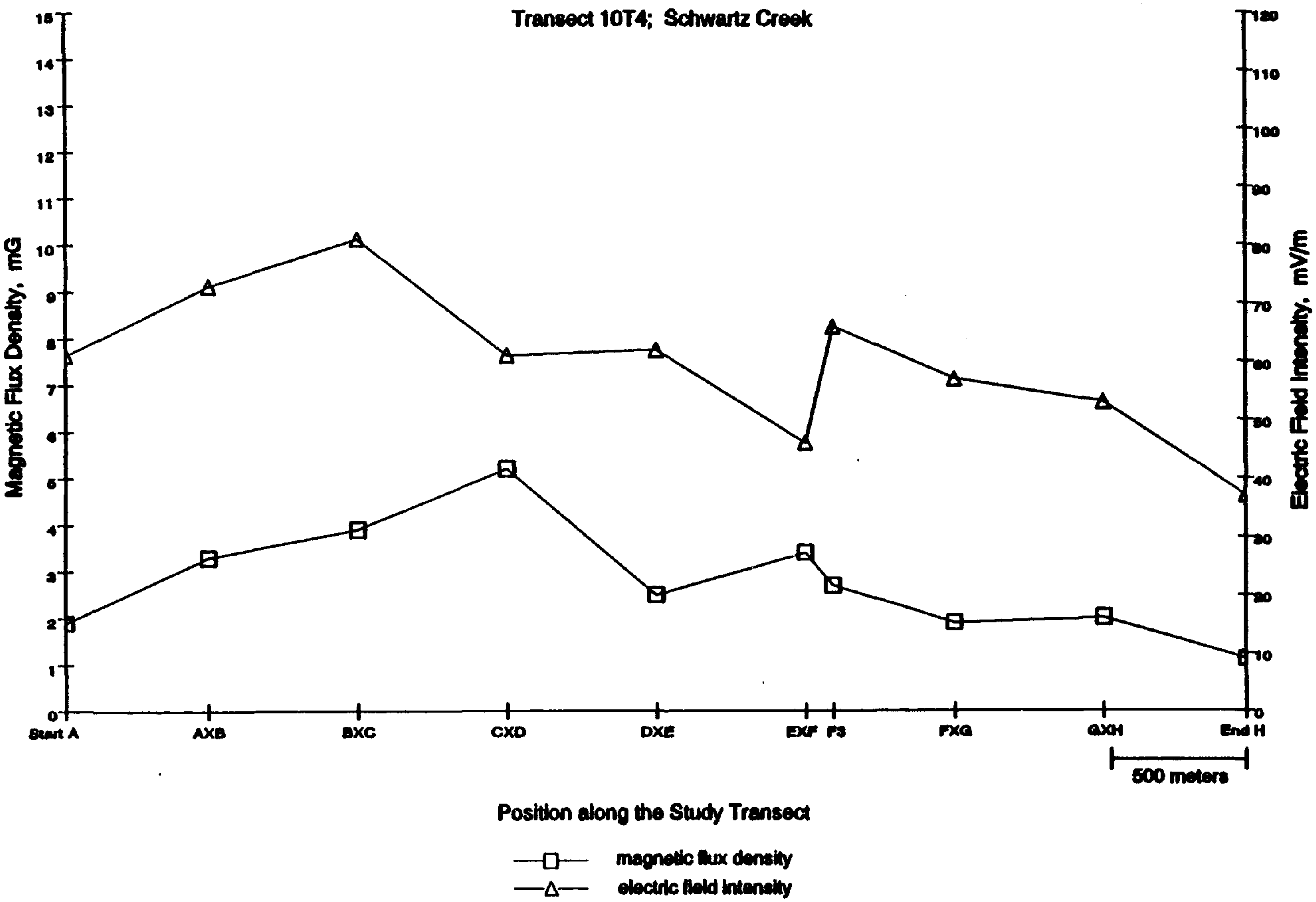



FIGURE 13. EM FIELD VARIATIONS ALONG STUDY TRANSECT 10T4.

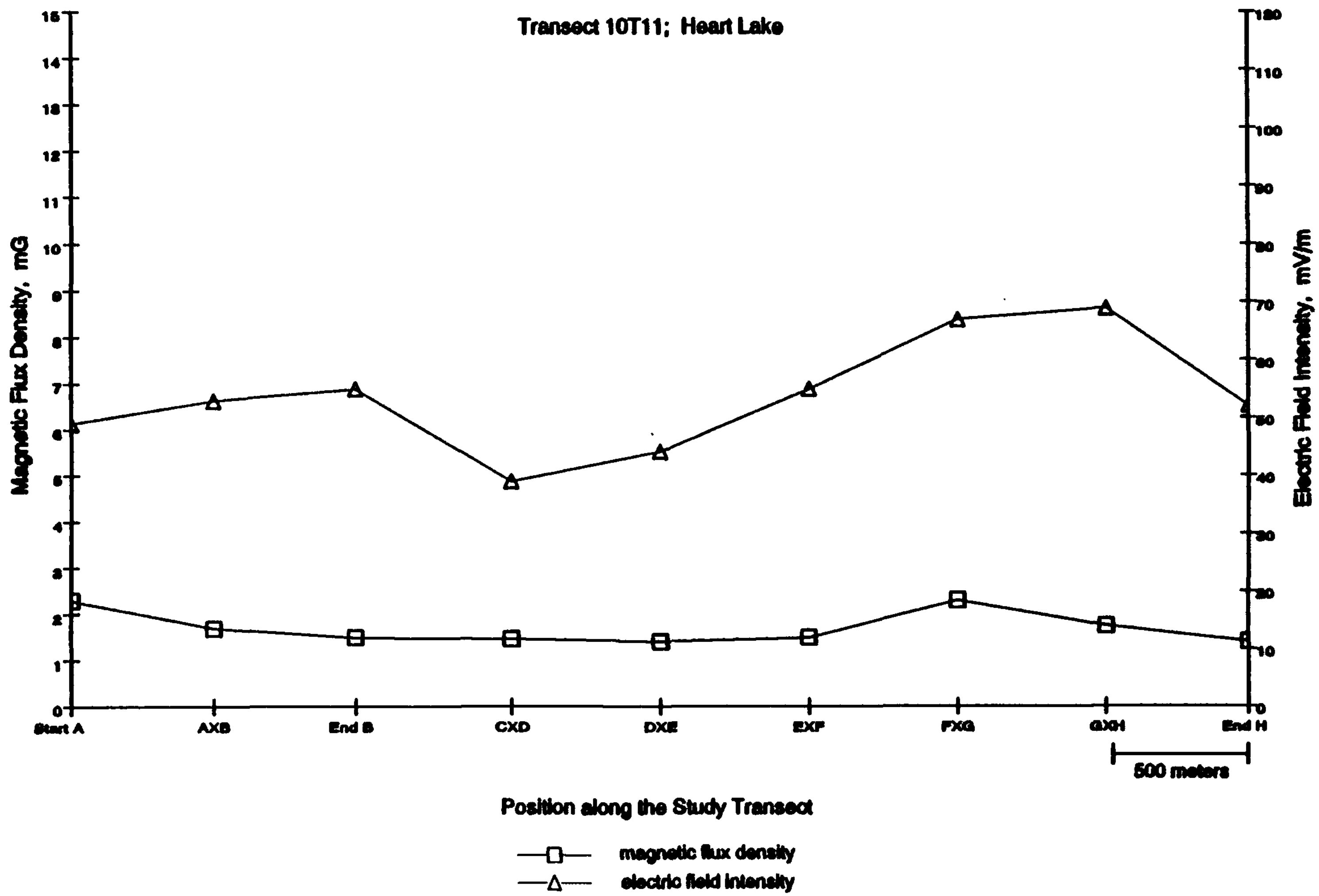



FIGURE 14. EM FIELD VARIATIONS ALONG STUDY TRANSECT 10T11.

### 4.2.2 Upland Flora and Soil Microflora Studies

In 1989, researchers for the upland flora and soil microflora studies requested detailed EM field intensity data for their treatment study sites so that exposures could be estimated for each tree on their plots. IITRI addressed this request in 1989 and 1990 by taking measurements to characterize the field profiles at these sites. In 1990, a rigorous earth electric field survey was performed that was used to generate field contour maps. Fixed electric field probes were installed at selected survey points and measured periodically to determine temporal variations of the longitudinal electric field. Each of these activities is discussed in the following sub-sections.

**4.2.2.1 EM Field Profiles.** Several historic measurement points at the treatment study sites have been selected along transects perpendicular to the antenna and ground ROWs to facilitate the characterization of EM field profiles across these sites. Profiles of the 76 Hz air electric field, magnetic flux density, and earth electric field for 1989 and 1990 appear in Figures 15-18. The historic measurement points that comprise each profile are identified in these figures and may be cross-referenced with the site layout maps in Figures D-3 and D-4 (see Appendix D). Measurement points 4T2-26 and 4T2-33 through 36 were not established in 1989; therefore, this profile does not exist for that year.

The air electric fields in the pine plantations at both the antenna and ground sites decrease in a uniform fashion with increasing distance from the antenna or ground feed wire. The 1990 fields are slightly less than those measured in 1989, which is likely the effect of increased shielding by the growing pine trees. At the ground site there is a dip in the field profiles near the plot center, which appears in both 1989 and 1990. This is caused by an interaction and cancellation of fields produced by the overhead feed and buried ground wires. These profiles may be used to estimate the air electric field intensity at any point in the pine plantations by graphic interpolation, given the distance of the point from the antenna or ground wires.

The air electric field profile for the pole stand and herbaceous reserve plots is not as uniform as that for the pine plantations. The air electric field, normally set up by the potential difference between the antenna wire and the earth, is shielded by the tall trees at these plots. The air electric fields that do appear at these plots are the by-product of the earth electric field, which creates potential differences between the trees. The air electric field profiles for these plots are therefore subject to the same variables that affect the earth electric field, as is shown by similarities in the profiles for these two fields. The earth electric fields vary significantly and unpredictably across the pole stand and herbaceous reserve plots, as discussed in the following paragraphs. The air electric field at other points on these plots, therefore, should not be estimated using the field profile data.

The magnetic flux density is dependent only on the distance of the measurement point from the source. The profiles for this field are therefore the most predictable and stable of those measured,

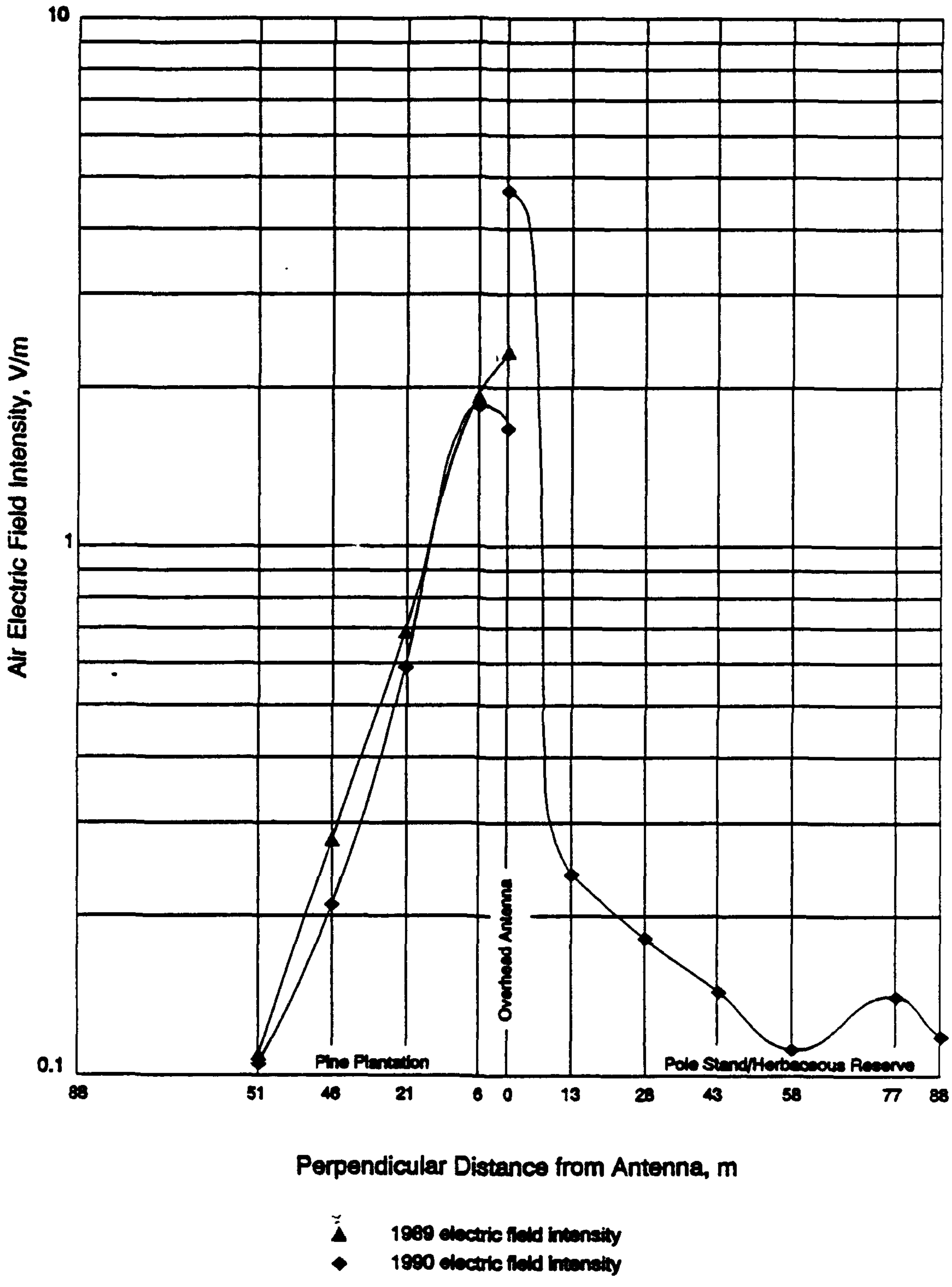



FIGURE 15. 76 Hz AIR ELECTRIC FIELD PROFILES, MARTELL'S LAKE (OVERHEAD): ML; 4T2-8, 9, 15-19, 26, 33-36.

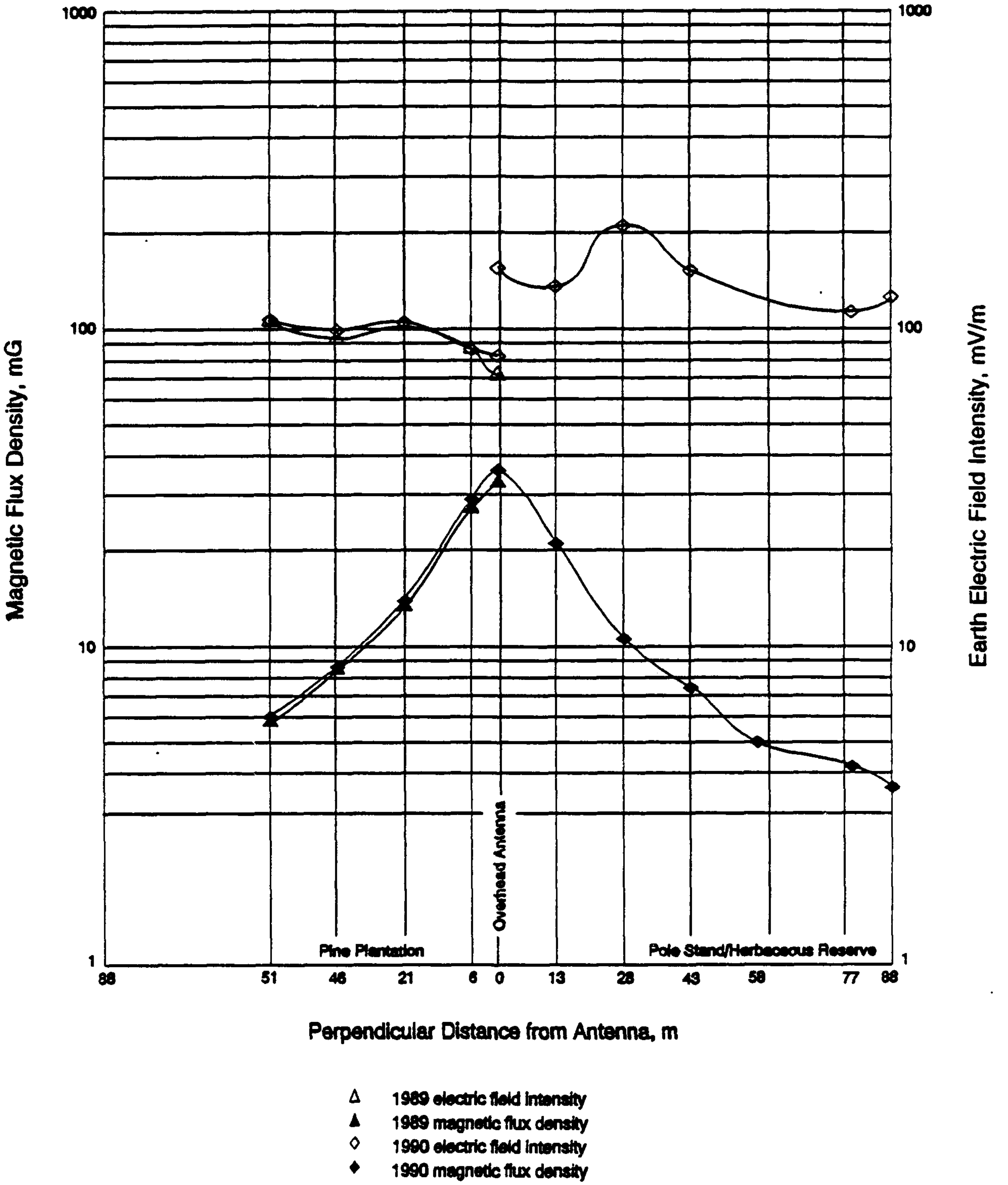



FIGURE 16. 76 Hz MAGNETIC AND EARTH ELECTRIC FIELD PROFILES, MARTELL'S LAKE (OVERHEAD): ML; 4T2-8, 9, 15-19, 26, 33-36.

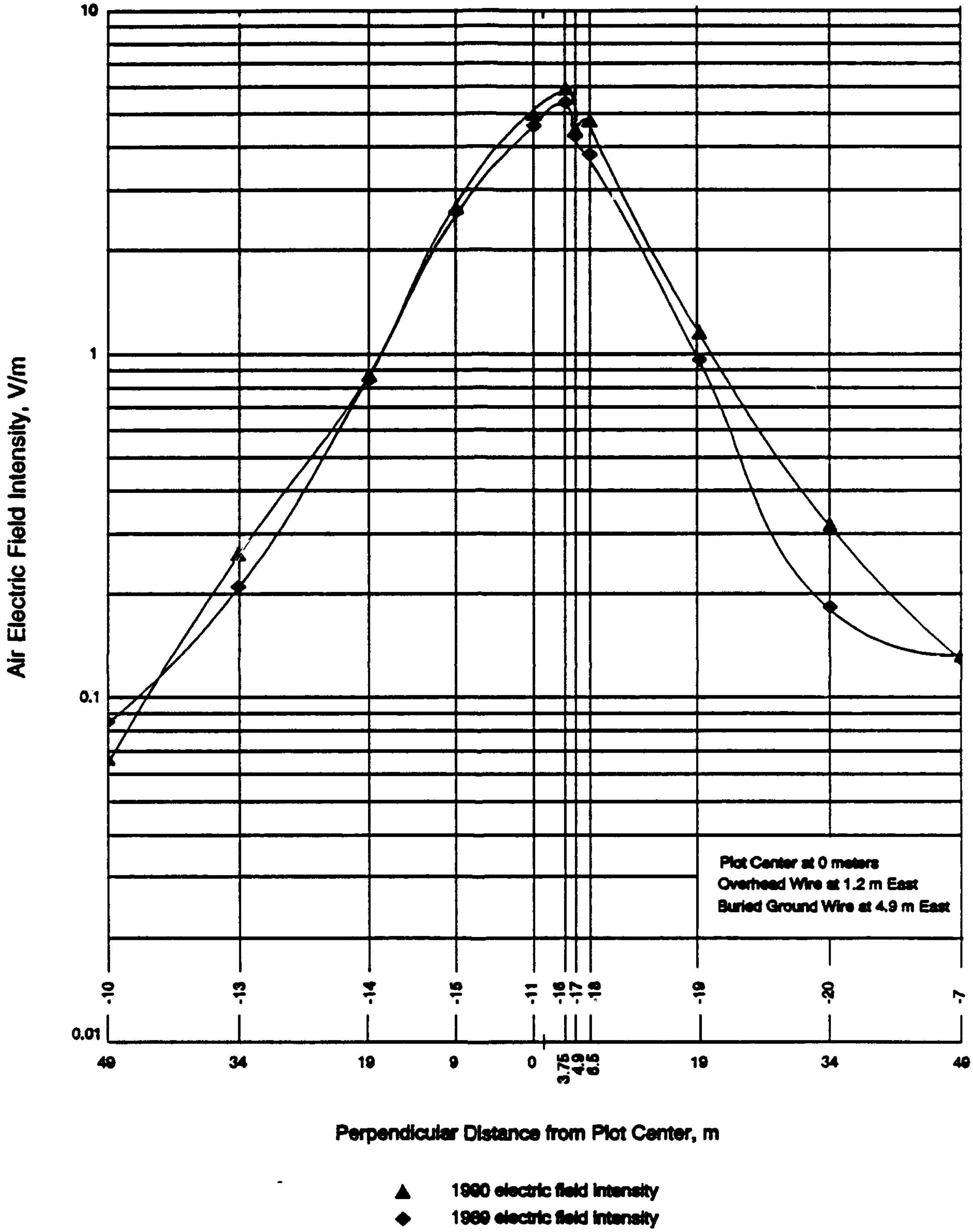



FIGURE 17. 76 Hz AIR ELECTRIC FIELD PROFILES, MARTELL'S LAKE (BURIED): EP; 4T4-7, 10, 11, 13-20.

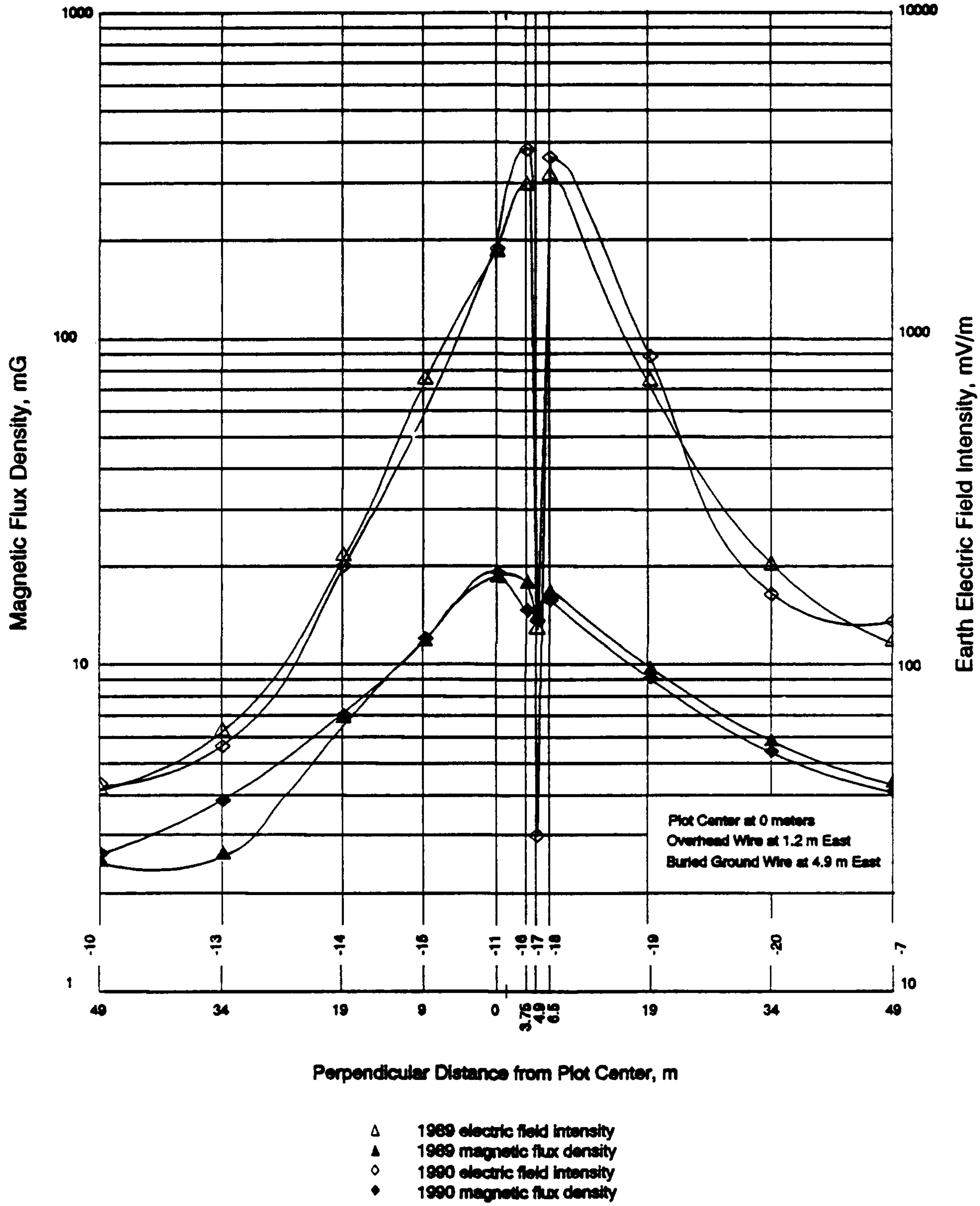



**FIGURE 18. 76 Hz MAGNETIC AND EARTH ELECTRIC FIELD PROFILES, MARTELL'S LAKE (BURIED): EP; 4T4-7, 10, 11, 13-20.**

decreasing uniformly with increasing distance from their sources. At the ground site, a dip in the magnetic flux density profile near the plot center, similar to that seen for the air electric field, appears in both 1989 and 1990. This is due to an interaction and cancellation of fields generated by the overhead feed and buried ground wires. These profiles may be used to estimate the magnetic flux density at any point at the treatment sites with very good accuracy.

The earth electric field at the treatment sites is influenced by several factors, making it very difficult to predict. At the antenna site, the field shows both increases and decreases with increasing distance from the antenna. Such irregularities are the result of varying terrain elevations and differences in soil conductivity.

The earth electric field at the ground site has a null over the buried ground wire, with relatively high peaks on both sides of the wire. This is characteristic of the earth electric field near an ELF ground wire. The earth electric field at the ground site falls off much more uniformly than at the antenna site, indicating that the soil conductivity is more consistent at the ground site.

Because the earth electric field behaves unpredictably across the treatment sites, it is not recommended that the historic profile data be used for field estimates at other points at these sites. Use of the historic data should be limited to year-to-year comparisons and for bracketing of field exposures.

**4.2.2.2 Earth Electric Field Contours.** Extensive earth electric field surveys were conducted to characterize the complex spatial field variations at the antenna and ground sites. These surveys consisted of a closely spaced grid of measurements from which electric field contours could be determined. Measurements were also taken near the monitoring equipment, where high field gradients were expected. The locations of the grid measurement points are mapped in Figures 19 and 20. Measured field intensity values are given at each point. EM field profiles similar to those in Figures 15-18 were drawn for each row and column of the grid. Graphic interpolation was then used to locate points of constant electric field intensity and to produce two-dimensional contour drawings of the earth electric field. The antenna and ground site contours are presented in Figures 21 and 22. These contour maps may be used to accurately estimate the earth electric field intensity at any point on the antenna and ground study sites.

Both the field survey and contour drawings show the locations of the ambient monitoring sensors. The sensors, as can be clearly seen from the contour maps, are surrounded by regions of high field intensities and field gradients. These are the result of ELF currents coupled to the sensor cable sheaths and grounding system installed for lightning protection. The maximum field intensities at the antenna site sensors are about twice the level of those at the ground site sensors because of differences in coupling at the two sites. Coupling levels are higher at the antenna site because the antenna currents are considerably larger than those in either the overhead or buried ground wires. Also, the orientation of the

(Text continues on page 52)

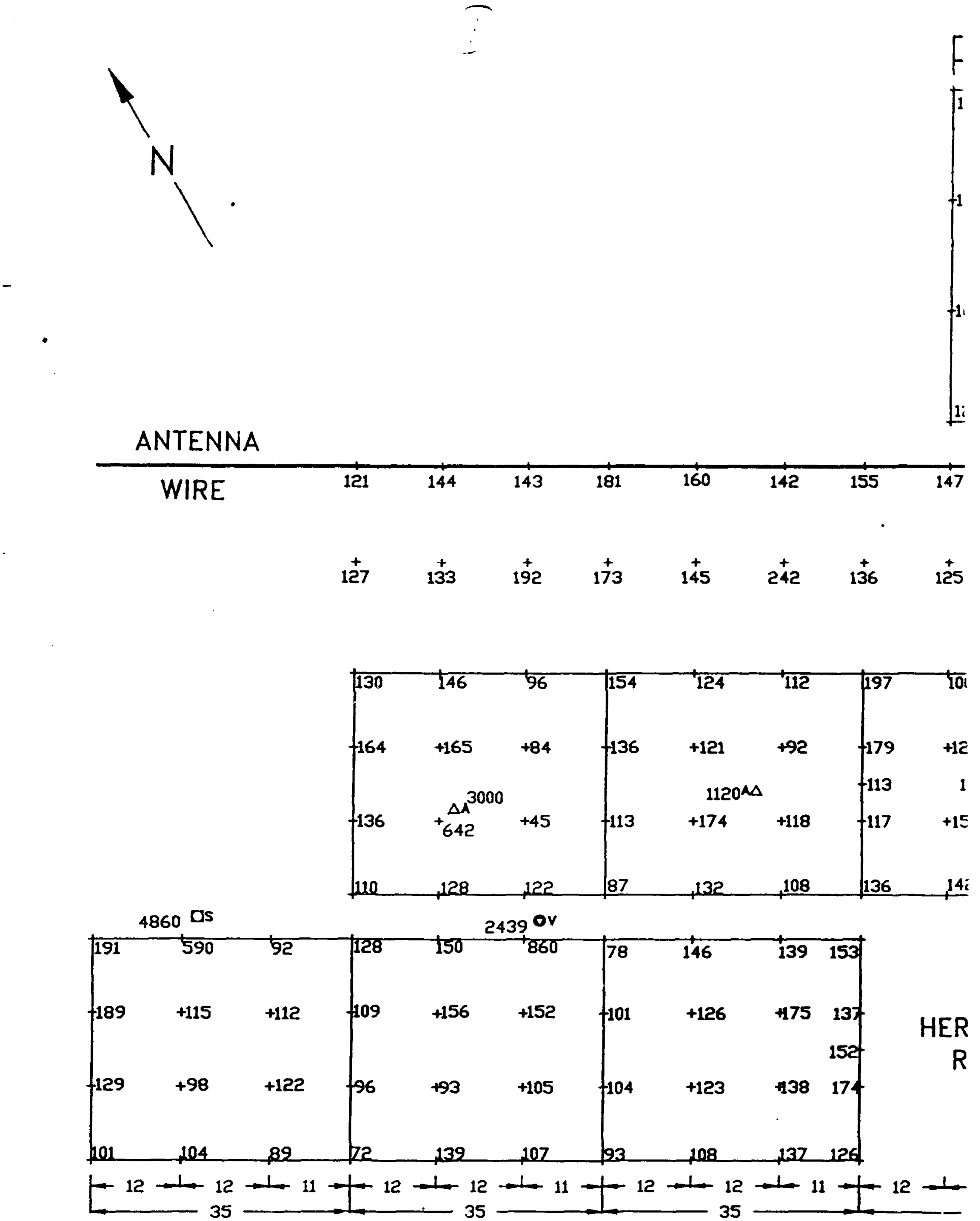



FIGURE 19. EARTH ELECTRIC
(OVERHEAD): MI

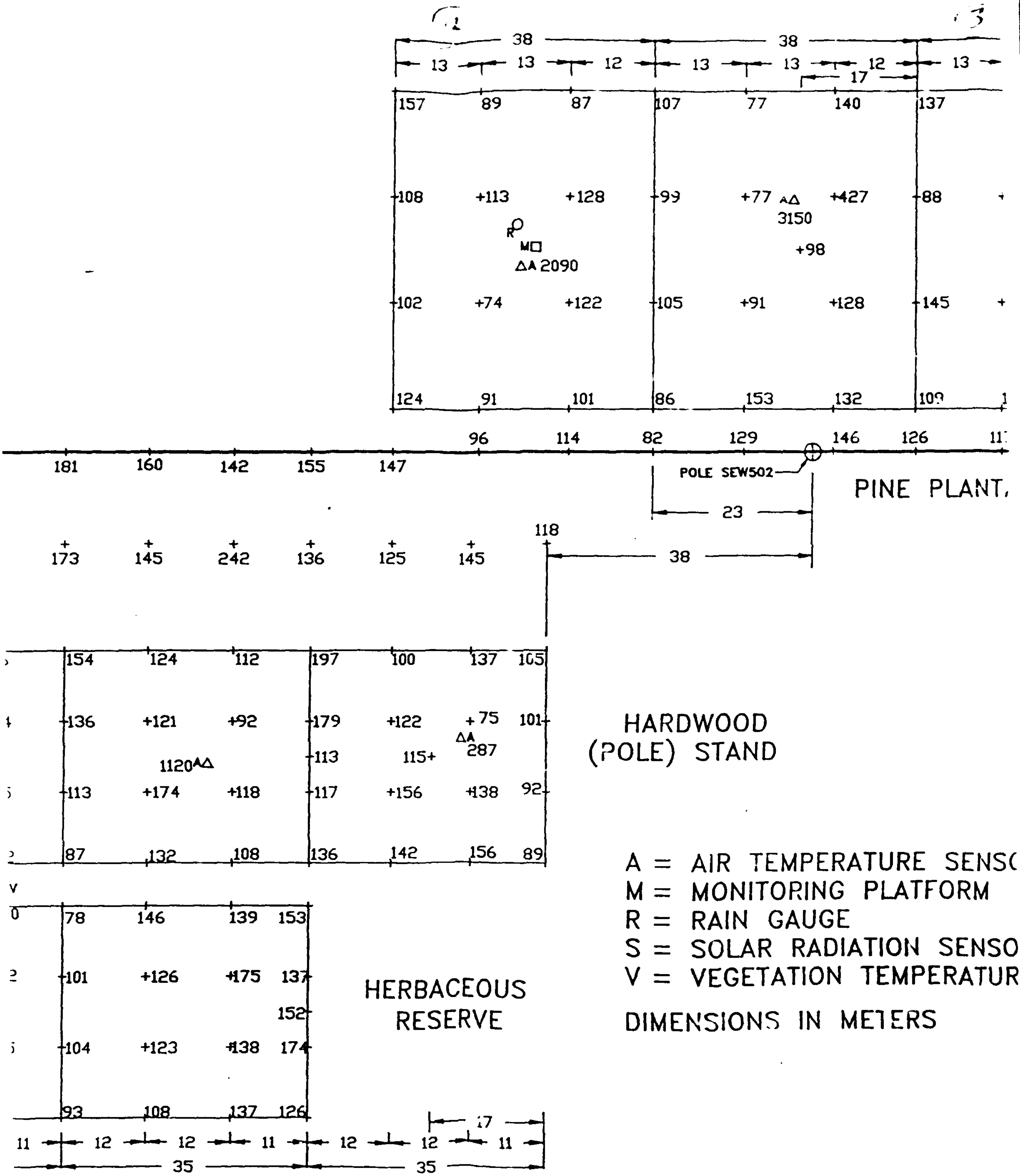
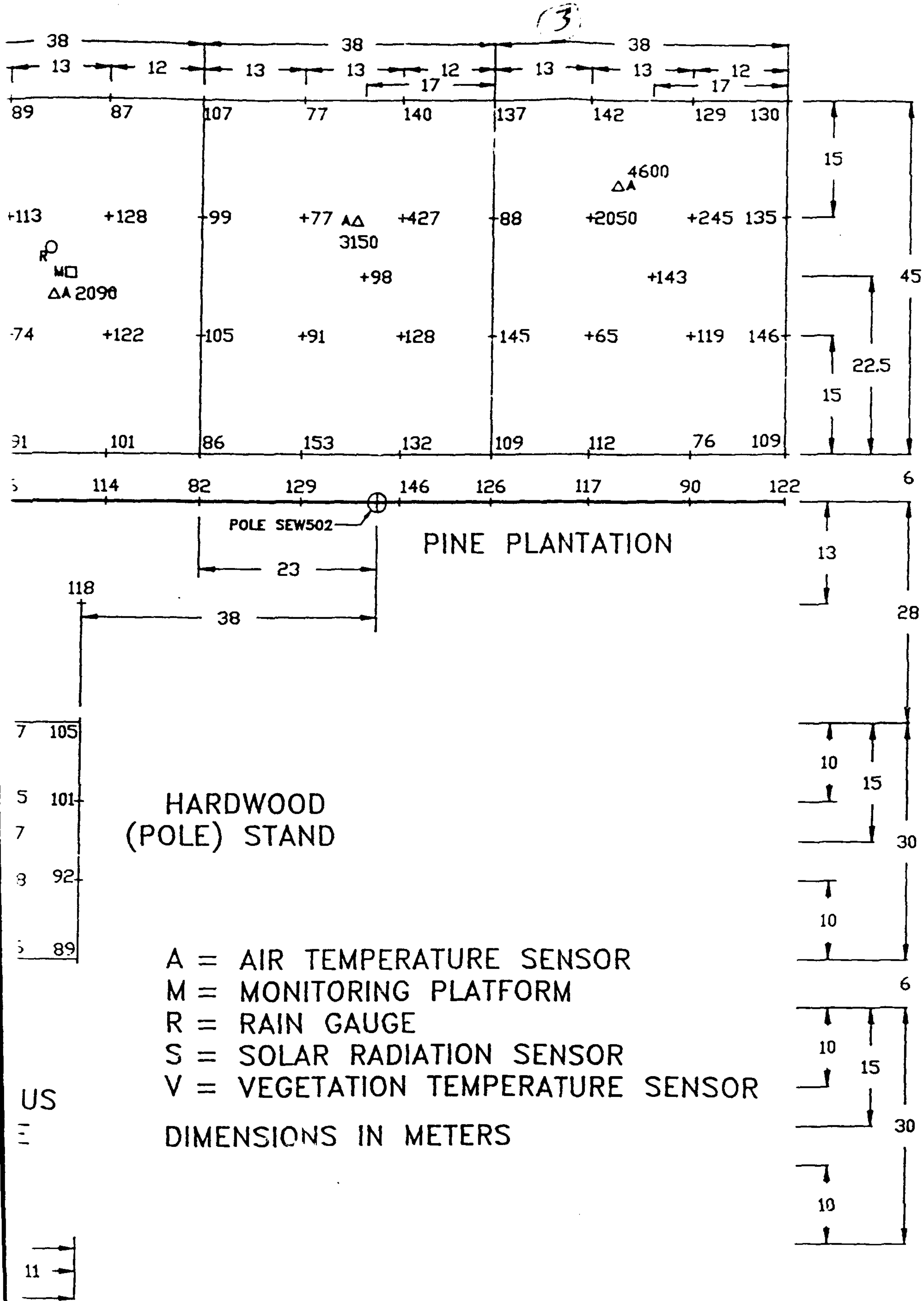



**FIGURE 19. EARTH ELECTRIC FIELD SURVEY (mV/m), MARTELL'S LAKE (OVERHEAD): ML; JUNE 1990.**




**URVEY (mV/m), MARTELL'S LAKE**
**1990.**

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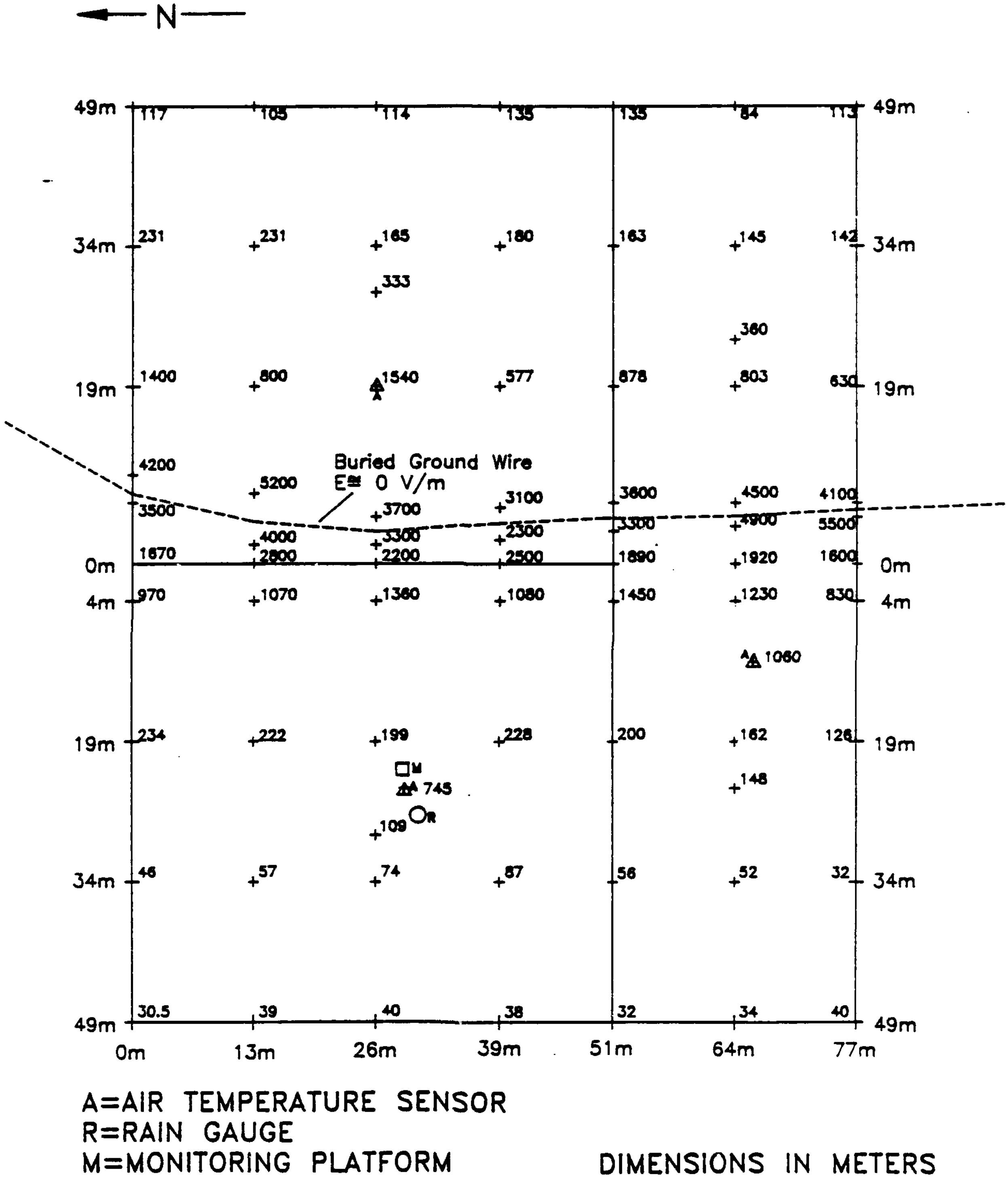



**FIGURE 20. EARTH ELECTRIC FIELD SURVEY (mV/m), MARTELL'S LAKE (BURIED): EP; JUNE 1990.**

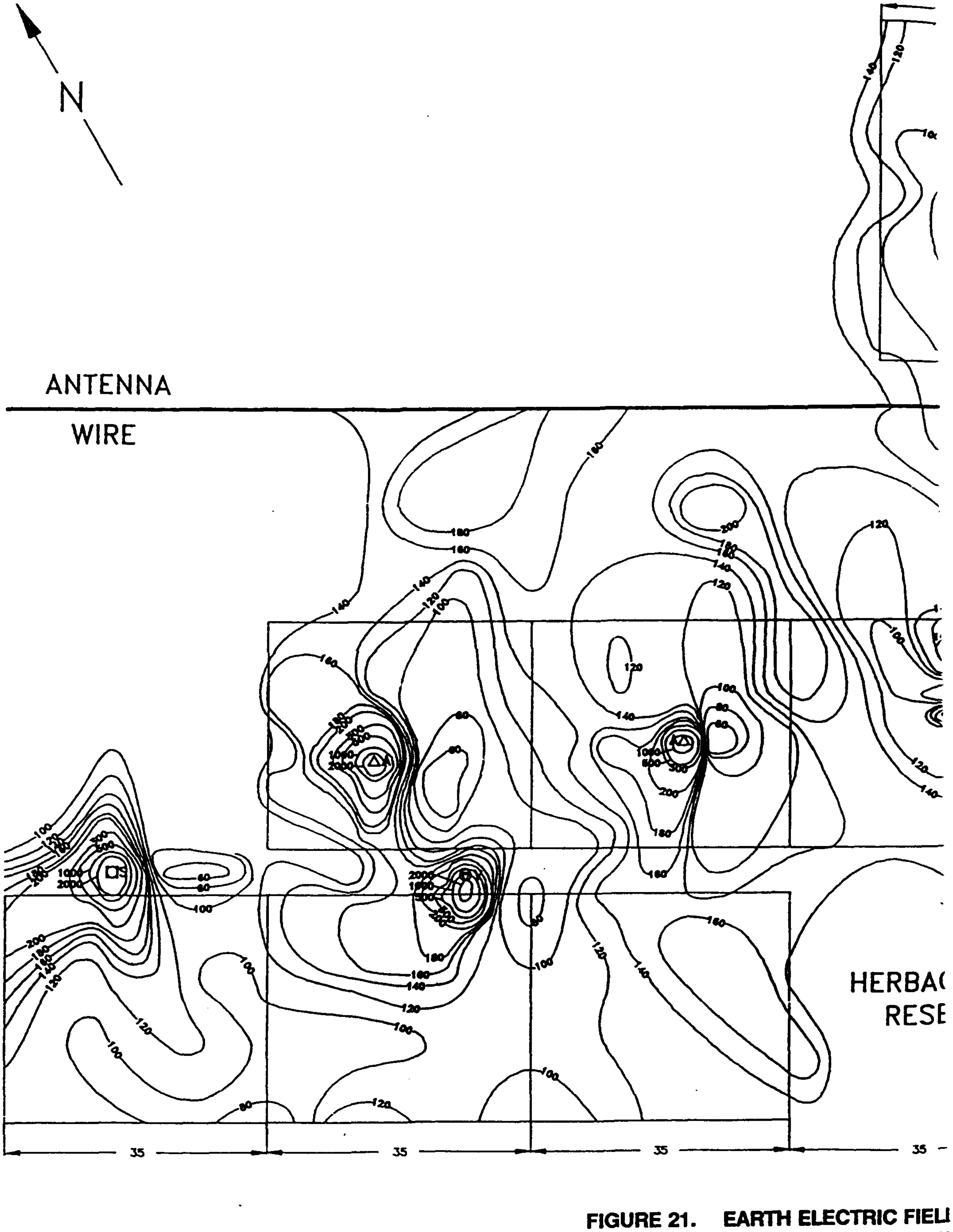



**FIGURE 21. EARTH ELECTRIC FIEL[**
**(OVERHEAD): ML; JUN**

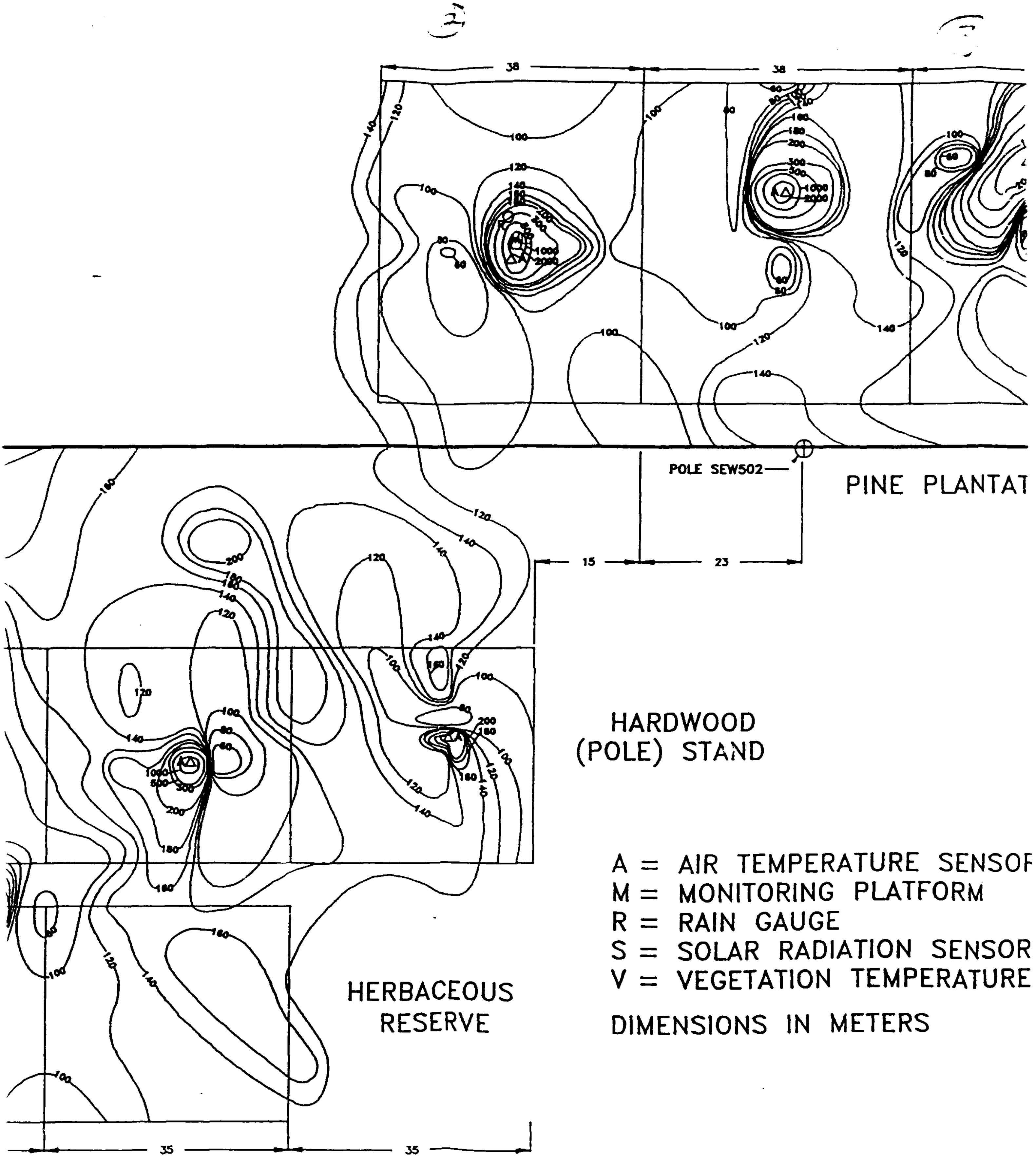
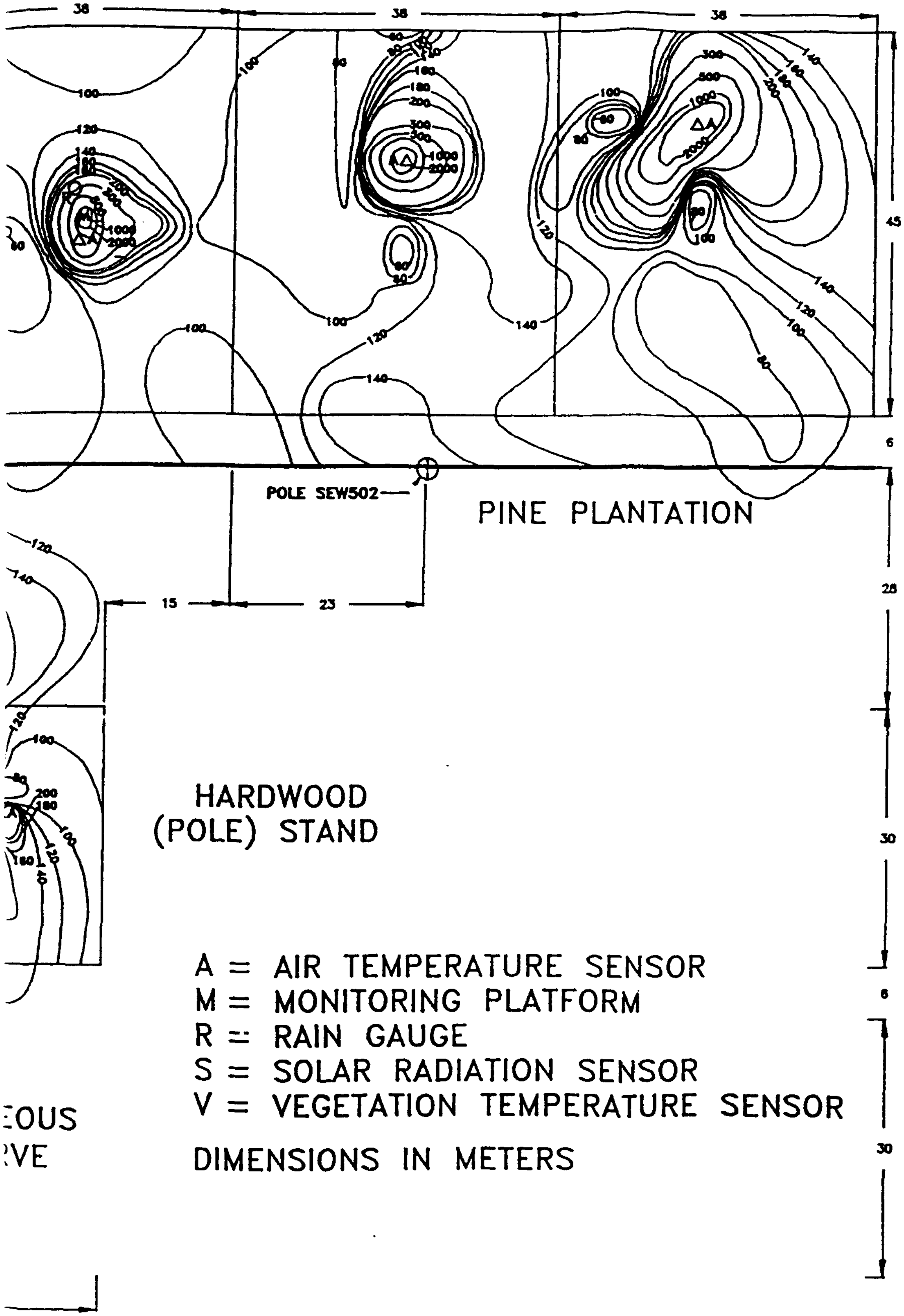
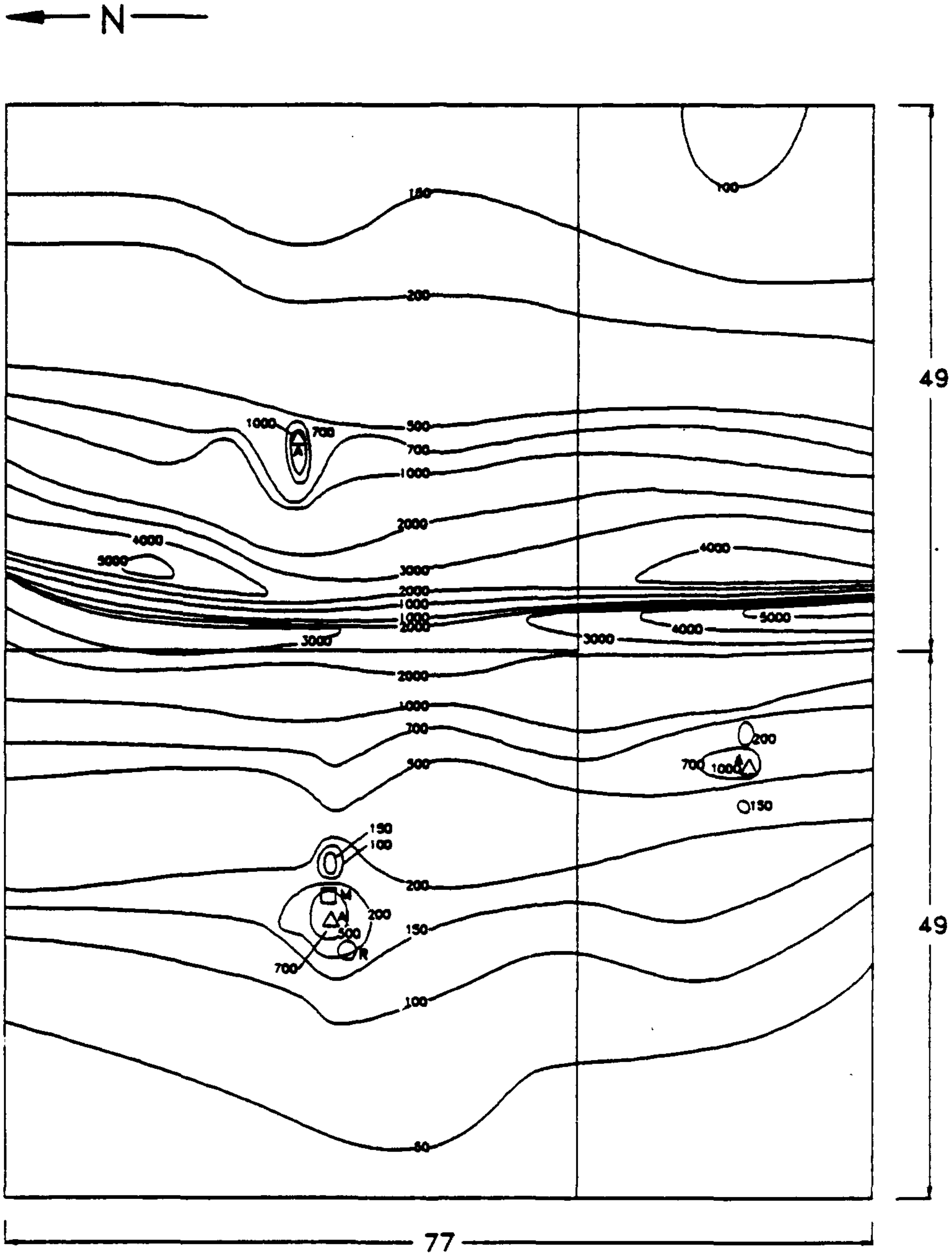



**FIGURE 21. EARTH ELECTRIC FIELD CONTOURS (mV/m), MARTELL'S LAKE (OVERHEAD): ML; JUNE 1990.**




CONTOURS (mV/m), MARTELL'S LAKE
1990.




A=AIR TEMPERATURE SENSOR
R=RAIN GAUGE
M=MONITORING PLATFORM

DIMENSIONS IN METERS

**FIGURE 22. EARTH ELECTRIC FIELD CONTOURS (mV/m), MARTELL'S LAKE (BURIED): EP; JUNE 1990.**

ground site sensor cables with respect to the ground wires makes them less susceptible to field coupling than the cables at the antenna site.

## 4.3 Temporal EM Field Variability

Annual EM field measurements generally have been made in late summer and early fall. Since most biota remain on the study sites throughout the year, the subject of EM field variations over the course of a year is important. Temporal variations related to the operating parameters of the ELF transmitters and to climatic variables such as temperature, rainfall, and soil moisture levels are expected. Mathematical descriptions of the fields are given here to show the functional relationships of the EM field variables and to provide a basis for understanding and predicting temporal variations. Measurements of EM field variations are presented in the following sub-sections.

### 4.3.1 Mathematical Field Descriptions

The top diagram in Figure 23 illustrates the orientation of the magnetic flux and earth electric field near an ELF antenna. The earth electric field near a buried ground wire and the air electric field near an ELF antenna are shown in the middle and bottom diagrams of the figure. Equations 5-8 provide a mathematical representation for the magnitude of each of these fields.

$$|B| = \frac{\mu_o I}{2\pi\sqrt{x^2 + h^2}} \qquad (5)$$

$$|E_{e1}| = -jf\, I\mu_o \ln\left(\frac{1.85}{x\sqrt{2\pi f \mu_o \sigma_e}}\right) - \frac{\pi f\, I\mu_o}{4} \qquad (6)$$

$$|E_{e2}| = \left(\frac{I}{\pi l \sigma_e}\right)\left(\frac{x}{x^2 + d^2}\right) \qquad (7)$$

$$|E_a| = \left(\frac{2V}{\ln\left(\frac{2h}{a}\right)}\right)\left(\frac{h}{h^2 + x^2}\right) \qquad (8)$$

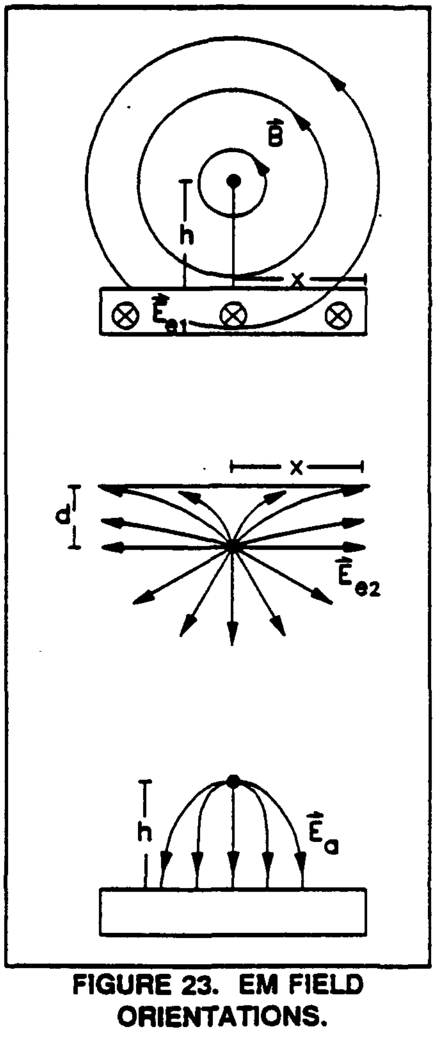



FIGURE 23. EM FIELD ORIENTATIONS.

where $B$ = magnetic flux density
$E_{e1}$ = induced earth electric field
$E_{e2}$ = conducted earth electric field
$E_a$ = air electric field
$I$ = antenna or ground wire current
$\mu_o$ = magnetic permeability in free space
$h$ = height of antenna wire
$x$ = horizontal distance to antenna wire
$V$ = voltage on antenna wire
$a$ = radius of antenna wire
$l$ = ground wire length
$d$ = depth of buried ground wire
$\sigma_B$ = bulk earth conductivity
$\sigma_s$ = surface earth conductivity
$j$ = $\sqrt{-1}$
$f$ = frequency of antenna current

The equations assume that the distance of the measurement point from the antenna or ground wire is small relative to the length of the antenna or ground wire, and they are valid for all treatment site measurement points. Although EM fields at the much more distant control sites are also dependent on the same variables, Equations 5-8 are not accurate predictors of the EM field intensities at control sites.

#### 4.3.2 Predicted Temporal Field Variability

The magnetic flux density is the least variable of EM fields. It is described by Equation 5, which is valid both in the air and the earth. This equation may also be used to predict the magnetic flux density resulting from ground wire currents by replacing "h" with "d." The magnetic flux density at any point is dependent only on antenna current and distance from the antenna. It is not expected to show seasonal variation, because it is not affected by the conductivity of surrounding vegetation and soil and it does not vary with the antenna frequency.

The total earth electric field at any point is the sum of that induced by the magnetic field and that generated by current conducted from the buried ground terminals. Equations 6 and 7 illustrate the differences in the earth electric field near antenna ROWs and ground terminals, respectively, as a function of current, frequency, and soil conductivity. Note that the conducted electric field is dependent on the ground wire current only, while the magnetically induced electric field is dependent on both the antenna current and the frequency. Thus, significant variations in the induced earth electric field are expected with changes in the antenna operating frequency. Electric field intensities for 44 Hz operation should be a little over half the intensities induced with 76 Hz operation. Smaller and less obvious changes in field intensity are also expected because of the MSK signal used by the ELF antennas (see Section 1.2). While this report generally refers to the MSK signal by its center frequency, in actuality the antenna frequency shifts between two frequencies 8 Hz apart. This changing frequency will also result in a changing induced electric field intensity.

In Equations 6 and 7, earth conductivity is the only variable that is expected to show a seasonal variation. In both cases, the field intensities are dependent on soil conductivity, which in turn varies with changes in soil moisture and temperature. The two conductivity terms (bulk and surface) are not equivalent, and have different functional relationships within the corresponding electric field equations. The earth electric field near ground terminals is dependent primarily on surface earth conductivity, while

bulk earth conductivity determines the electric field near antenna ROWs. The bulk earth conductivity is a weighted average of the surface and deep earth conductivities. Because the deep earth conductivity remains stable throughout the year, the bulk earth conductivity shows less seasonal variation than does the surface earth conductivity.

In addition to these differences in effective conductivity, the earth electric field near ground terminals varies in inverse proportion to conductivity, while the earth electric field along antenna ROWs varies in proportion to the natural logarithm of the inverse of the square root of conductivity. Thus, the earth electric field is almost twice as sensitive to changes in conductivity near ground terminals as it is to changes in conductivity along antenna ROWs. This fact, in conjunction with the expected higher variation in surface conductivity, indicates that the greatest seasonal variations in earth electric fields will occur along ground terminal ROWs. Additional earth electric field variability can result if either conductivity term is itself frequency-dependent.

The air electric field in an ROW or a clearing near the antenna is essentially dependent only on the antenna voltage, and the distance to and height of the antenna wire. It should be noted that the antenna voltage is constant for a given antenna current, and there is no frequency-dependent term in Equation 8. The air electric field is also independent of soil conductivities and humidity. Therefore, it is not expected to show climatic-induced variation at unshielded locations throughout the year. However, at other locations where the air electric field is shielded by vegetation and trees, or generated as a by-product of the earth electric field, more seasonal variation is expected as plants enter dormancy and leaves fall, or as the earth electric field varies. Such variations in the air electric field would be difficult to quantify to any useful degree.

#### 4.3.3 Measured Frequency-Related Electric Field Variations

The expected variations in the induced earth electric field caused by antenna frequency changes have in fact been observed in measurements made during periods of 44 Hz and 76 Hz antenna operations. The upper half of Figure 24 provides a sample of hourly data logger earth electric field measurements taken at the soil amoeba antenna study site during 150 ampere operation of the NRTF-Republic with 44 Hz and 76 Hz CW and MSK signals. Clearly evident in this figure are the expected major shifts in electric field intensity between periods of 44 Hz and 76 Hz operation. Also detectable are the less dramatic electric field variations that are associated with the MSK modulation. The amount of field variation measured during MSK operation (9-10% at 76 Hz, 16-17% at 44 Hz) is consistent with the percent frequency shift of the MSK signal. Similarly, the 44 Hz and 76 Hz field intensity levels are proportional to the signal center frequency.

The earth electric field near a ground terminal is the sum of both induced and conducted electric fields. The conducted electric field set up by leakage currents off a buried ground wire is not frequency-

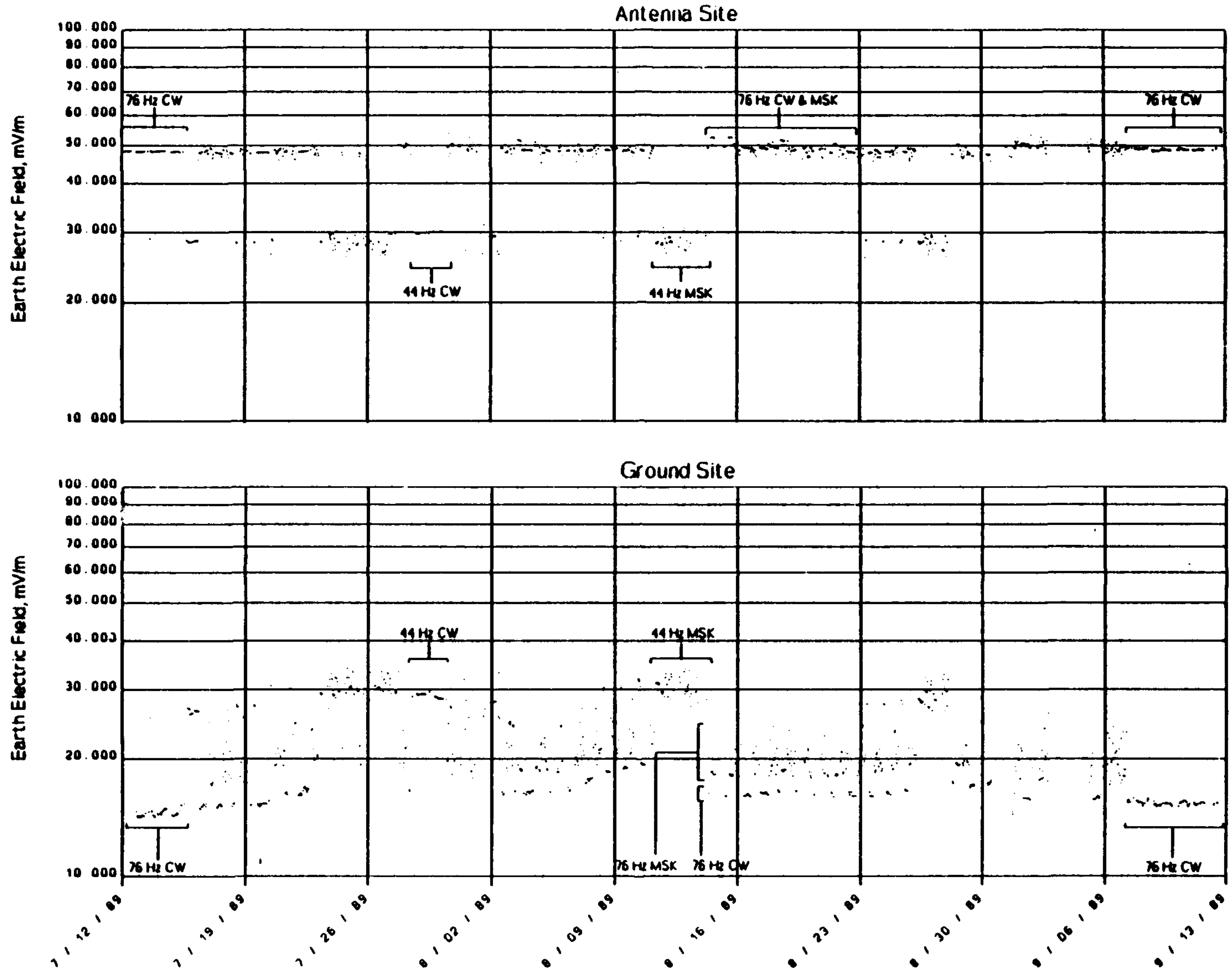



FIGURE 24. FREQUENCY-RELATED EARTH ELECTRIC FIELD VARIATIONS AT THE SOIL AMOEBA STUDY SITES.

dependent, and therefore the sum of the earth electric fields at a ground ROW should have less frequency-dependence than earth electric fields in an antenna ROW. Frequency-dependent variations in the earth electric field have been seen in data logger measurements at the soil amoeba ground study site, as shown in the lower half of Figure 24. This site is unique, however, in that four sources of earth electric field are present here and appear to be interacting. These sources are: the end of the NS antenna, the overhead ground feed wire, the buried horizontal ground wire, and two vertical well ground arrays. Because the currents in each of these sources are at different phases, the field variations produced are unique, complex, and essentially unpredictable. As shown in Figure 24, the field variations resulting from MSK modulation are much greater than those expected by the amount of frequency shift. Further, the field intensities during 44 Hz operation are greater than those during 76 Hz operation, the opposite of what was expected. The mechanisms behind the earth electric field variations with frequency at the soil amoeba ground study site are not completely understood. However, the extent of the anomalous area has been shown by additional spatial measurements to be limited to a short span along the ground ROW.

The primary function of the data loggers is to study seasonal variations in the earth electric field. These longer-term variations can be masked to some extent by the more frequent variations resulting from MSK modulation. Therefore, the data loggers were equipped in late 1990 with additional low-pass filtering circuits to remove, or smooth out, these higher frequency variations. Measurements taken prior to the installation of the filters can be "smoothed" mathematically by computing the average of measurements taken over a 24-hour period.

#### 4.3.4 Measured Seasonal Electric Field Variations

**4.3.4.1 Fixed Probe Seasonal Measurements.** The contour drawings in Figures 21 and 22 provide for the most accurate earth electric field estimates at the upland flora in soil microflora treatment study sites. They do not, however, provide information on the temporal variation of these field intensities. For this reason, fixed earth electric field probes were installed at 40 measurement point locations at the antenna and ground treatment sites for these studies. The fixed probe locations are shown, together with the historic measurement points, in Figures D-3 and D-4 (see Appendix D). Some of these measurement locations are the same as historic measurement point locations, while the others are unique. Fixed probe measurements have been taken twice a month, with the expectation of identifying long-term or seasonal variations at these points. Fixed probe measurements and summary statistics for June 1990 through January 1991 are listed in Tables D-9 and D-10. With few exceptions, the fields at the fixed probes have shown no significant variations, having coefficients of variation typically at or below 10%. Exceptions noted at points 4T4-4, 9, and 12 are believed to be related to changes in soil-to-electrode contact impedance.

The fixed probe measurements provide a good overview of the variations in the earth electric field at the treatment study sites over long time periods. A more detailed temporal study of earth electric field variations, using data loggers, may be implemented in 1991. Such loggers would make hourly measurements of the earth electric field at selected measurement points to provide information on daily as well as long-term field variations.

#### 4.3.4.2 Data Logger Seasonal Measurements

Data loggers installed at the soil amoeba study sites in 1988 have operated continuously since then, except for maintenance, in order to monitor seasonal variations in the earth electric field. Electric fields are measured at two probe sets at each of the study's two treatment sites: one site adjacent to the NS antenna, and one site adjacent to the NS antenna south grounding element. The EM fields at both sites are thus dominated by the NS antenna. Figures 25 through 28 present plots of the average electric field intensities at these sites, calculated daily, for the period from June 1988 to January 1991. Daily average computations were based only on the hourly measurements taken when the NS antenna was operating either by itself or simultaneously with the EW antenna. No data are plotted for days when the NS antenna did not operate. Earth electric field intensities at these sites generated by exclusive operation of the EW antenna were below the input sensitivity of the data loggers.

The data in these figures reflect changes in the NRTF-Republic operating frequency and currents as well as seasonal variations. For example, on 22 July 1988, the current being fed into the section of buried horizontal ground wire adjacent to the ground study site was decreased as part of a redistribution of ground currents. This led to a proportional decrease in the electric field at that site, as illustrated in Figures 27 and 28. In 1989, antenna operating currents were increased from half power, (75 amperes) to full power (150 amperes), which resulted in a proportional increase in the electric field intensity at both sites.

Changes in field intensity caused by the frequency shifts inherent in MSK modulation have been "smoothed" by averaging the hourly measurements, and are therefore not evident in these figures. However, intensity changes caused by the shift from 44 Hz to 76 Hz operation can be clearly seen at the antenna site in 1988, when the NRTF-Republic operated for extended time periods at each of these frequencies. Both operating frequencies were also employed in 1989, but the 44 Hz and 76 Hz periods of operation are less distinguishable because both frequencies were often tested for short time periods on the same day. Thus, the daily average field intensity values plotted are weighted by the operating time at each frequency.

In general, the earth electric fields near the antenna ROW are very predictable if the antenna operating parameters are known. When the effects of frequency and operating parameters are excluded,

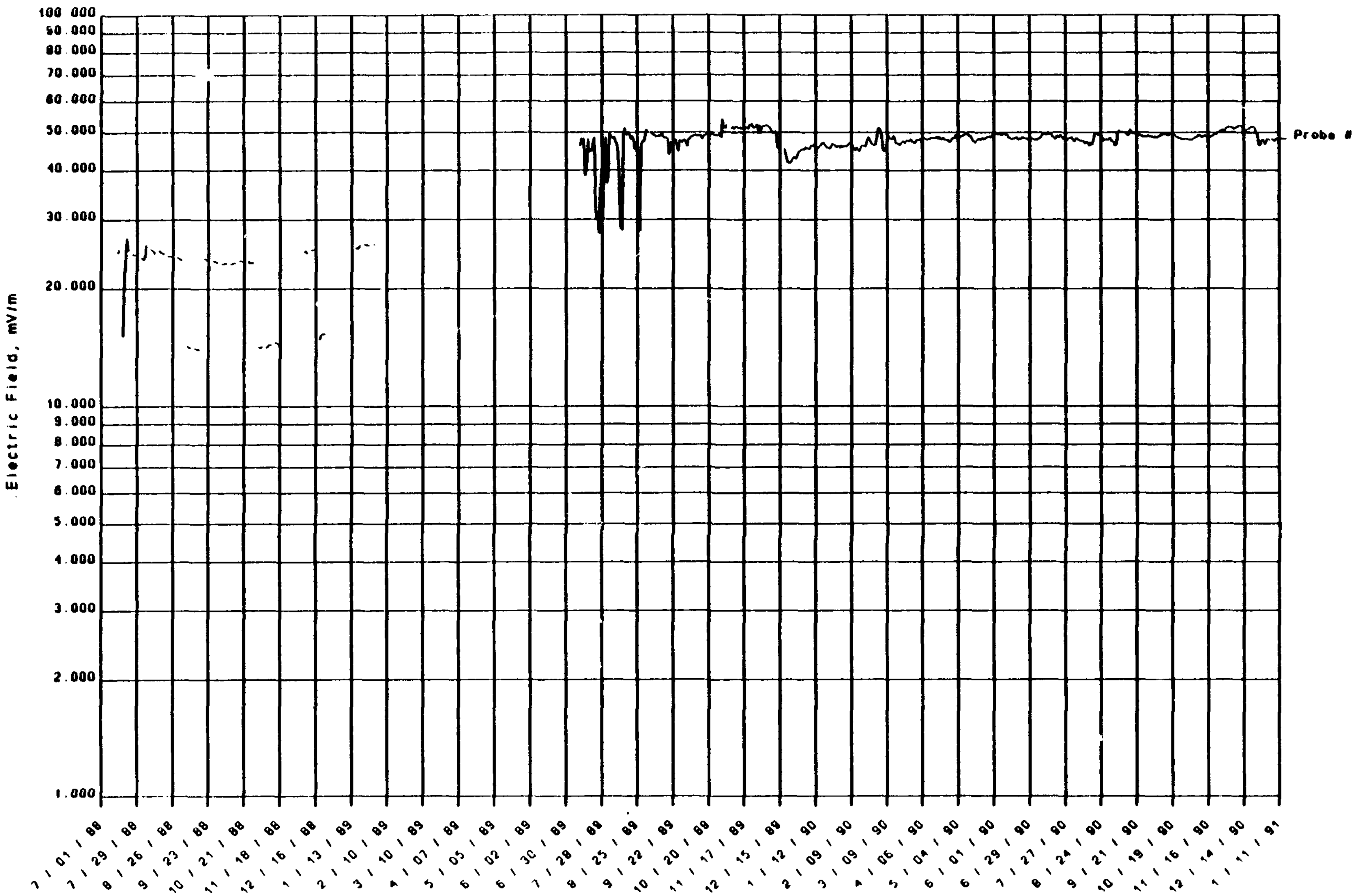



FIGURE 25. DAILY AVERAGE EARTH ELECTRIC FIELD INTENSITIES FOR PROBE #1 AT THE SOIL AMOEBA ANTENNA STUDY SITE.

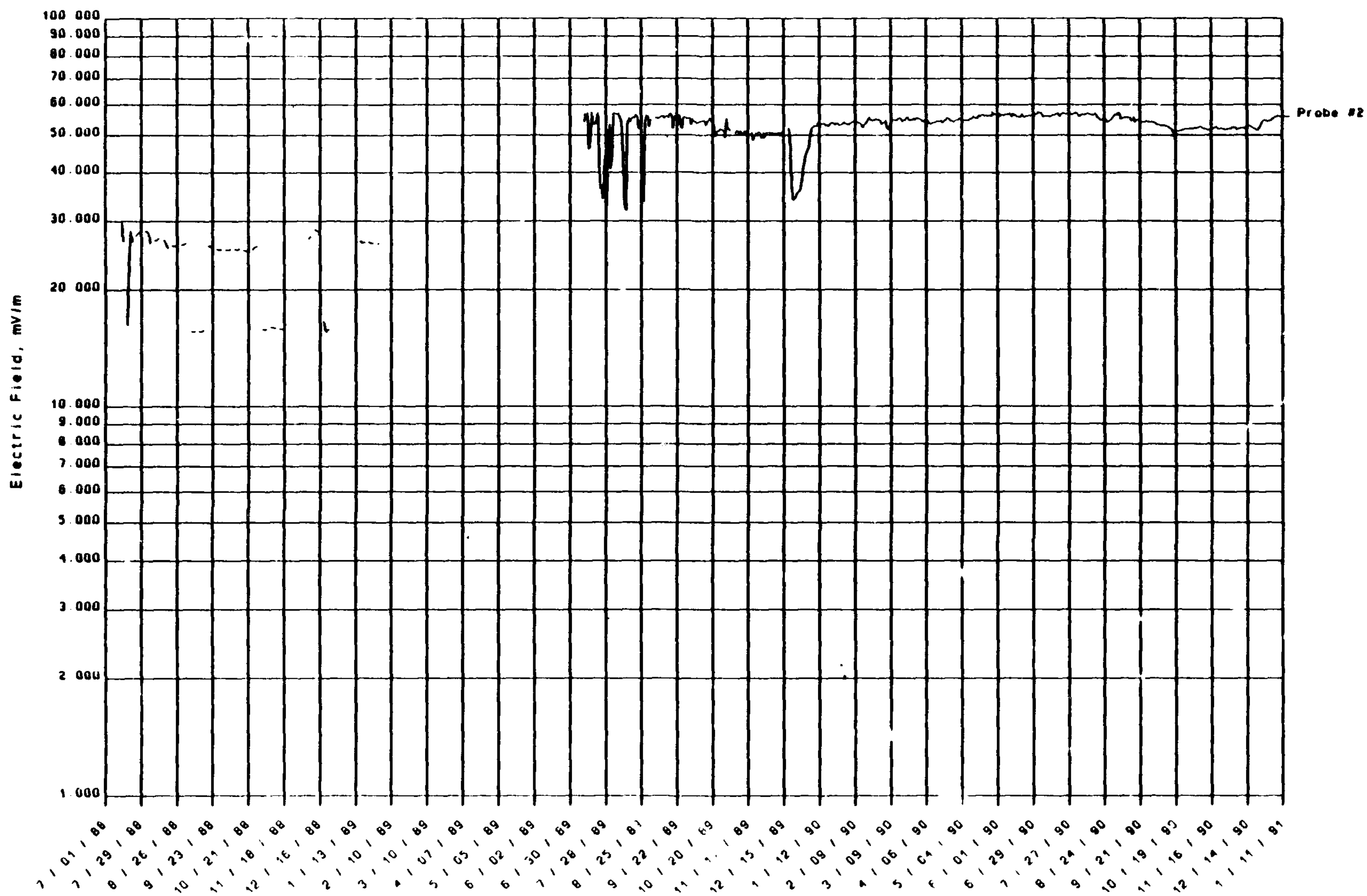



FIGURE 26. DAILY AVERAGE EARTH ELECTRIC FIELD INTENSITIES FOR PROBE #2 AT THE SOIL AMOEBA ANTENNA STUDY SITE.

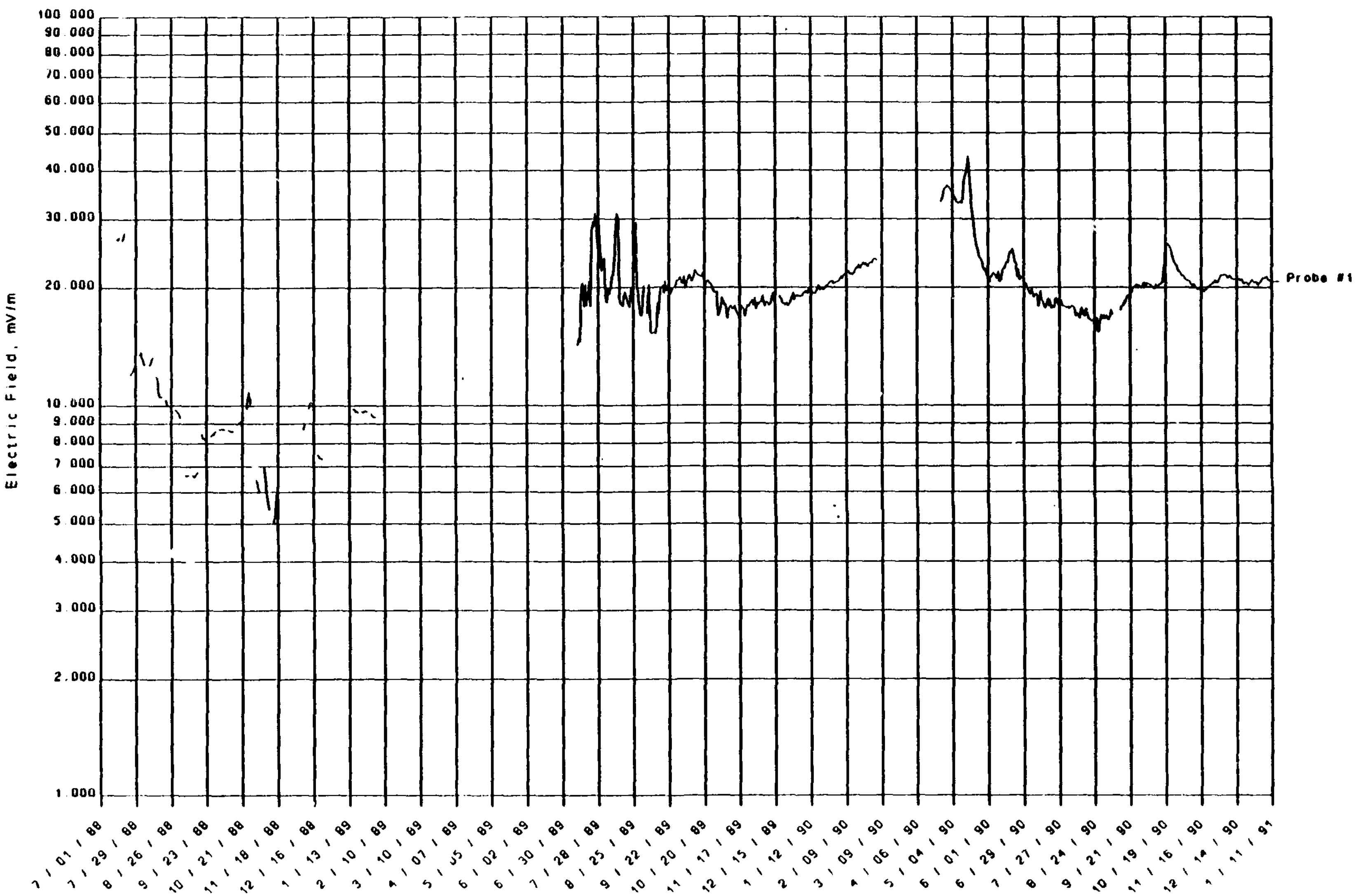



**FIGURE 27. DAILY AVERAGE EARTH ELECTRIC FIELD INTENSITIES FOR PROBE #1 AT THE SOIL AMOEBA GROUND STUDY SITE.**

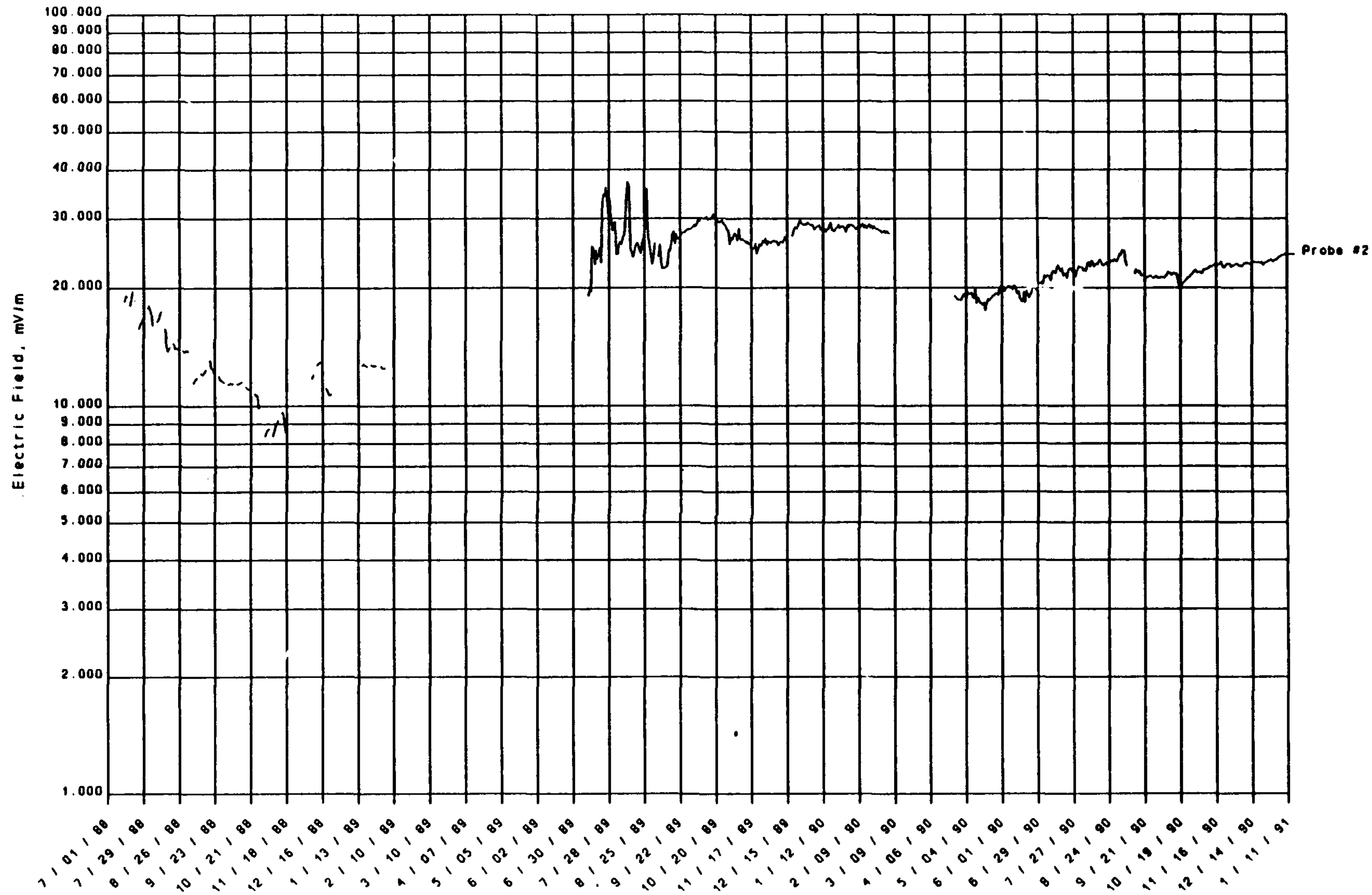



**FIGURE 28. DAILY AVERAGE EARTH ELECTRIC FIELD INTENSITIES FOR PROBE #2 AT THE SOIL AMOEBA GROUND STUDY SITE.**

seasonal electric field variations caused by changes in soil properties related to factors such as rainfall and temperature are shown to be nominally on the order of ±5%. The earth electric fields near the ground ROW, on the other hand, are difficult to predict. The amount of electric field variation that appears to be attributable to seasonal factors at the ground site is as large as 100%. Considerable differences are also seen between the two sets of electric field probes at the ground site. Preliminary analyses suggest that rainfall and the freeze/thaw cycle are the primary contributors to seasonal variations in the earth electric field at the ground sites.

The soil amoeba and upland flora and soil microflora studies are the only studies in Michigan having treatment sites situated in or near ground terminal ROWs. All other studies are along antenna ROWs. Seasonal variations in the earth electric field can be expected to have the greatest impact on studies investigating subterranean biota, i.e., the soil arthropods and earthworms studies, the upland flora and soil microflora studies, the soil amoeba studies, and the aquatic ecosystems studies.

The aquatic ecosystems studies are performed in the stream bed of the Ford River, which is always water-saturated. Soil-moisture-related earth electric field variations are therefore not expected at these study sites. Seasonal variations in the river's ion concentrations, however, may affect the water conductivity and hence the earth electric field intensities at these sites. This variability will be examined in 1991 by installing a data logger to monitor stream bed electric field intensities at the treatment site for this study.

#### 4.3.5 Monitoring of Soil Amoeba Culture Cell EM Fields

The soil amoeba studies use sealed culture cells that isolate the study organisms from the surrounding soil. This in vitro procedure allows close monitoring of biotic end points without contamination from other soil organisms and bacteria. The culture cells are buried in the earth at shallow depths at treatment and control sites, thus exposing the cultures of soil amoebae to the earth's ambient temperature and to the ELF and 60 Hz magnetic fields present there. It is also desirable to expose the amoebae to the same electric fields that they would encounter if living in the soil. Ideally, this would be accomplished simply by connecting electrodes in the culture cell directly to the earth, so that the voltages and currents present in the earth could be applied to, and flow through, the culture medium in the cell. However, the electric field exposure in the culture cells is complicated by a mismatch between the conductivity of the soil and that of the culture growth medium.

Therefore, external control circuitry is used to regulate the drive voltages that are applied to the culture cell electrodes. Collector electrodes in the earth supply the raw drive voltages. Two basic culture cell drive control circuits were developed: one for matching electric field exposure in the culture cell to that in the earth, and the other for matching current density exposure. Drive control circuits and protocols

explaining their use are detailed in Appendix I. Magnetic flux is not perturbed by the culture cells or the earth.

Culture cells and control apparatus have been installed at the soil amoeba study sites during the years 1987-1990. Control voltages $V_{\alpha}$ and $V_R$ and open circuit voltage $V_{OC}$ were measured according to the protocol outlined in Appendix I. Culture cell electric field ($E_{\alpha}$) and current density ($J_{\alpha}$) are calculated from the measured voltages as follows:

$$E_{\alpha} = \frac{V_{\alpha}\ \text{(volts)}}{0.113\ \text{m}} \quad \text{(V/m)} \tag{9}$$

$$J_{\alpha} = \frac{V_R\ \text{(volts)}}{R\ \text{(ohms)}\ 1.42 \times 10^{-4}\ \text{m}^2} \quad (\text{A/m}^2) \tag{10}$$

where 0.113 *m* is the measured distance between culture cell electrodes, and $1.42 \times 10^{-4}$ $m^2$ is the cross-sectional area of the culture cell growth medium, assuming a cell *half full* of medium.

IITRI designed and installed microprocessor-controlled data loggers in 1988, to continuously monitor the culture cell electric fields and current densities. These and other parameters measured by the data loggers in each year are summarized in Table 4. Plots of the earth electric field measurements for 1988-1990 were presented and discussed in Section 4.3.4.2. Rainfall and temperature data are being taken for possible future engineering analyses and are not presented in this report.

**TABLE 4. PARAMETERS MEASURED BY SOIL AMOEBA DATA LOGGERS**

| Measurement Parameter | 1988 | 1989 | 1990 |
|---|---|---|---|
| Earth Electric Field | • | • | • |
| Culture Cell Voltage and Current | • | • | • |
| Data Logger Case Temperature (Soil Temperature Surrogate) | • | • | • |
| Soil Temperature | | • | • |
| Rainfall | | | • |

Figures 29 through 40 present plots of the calculated culture cell current densities and electric field intensities at the antenna and ground treatment sites for the 1988, 1989, and 1990 field seasons. Listings of these values are provided in Appendix F. As in the case of the earth electric field data, daily average computations were based only on the hourly measurements taken when the NS antenna was operating either by itself or simultaneously with the EW antenna. No cell data are plotted for days when the NS antenna did not operate. Accurate cell measurements were not possible at the treatment sites during exclusive operation of the EW antenna, nor at the control site under any conditions, because the cell voltage levels were below the input sensitivity of the data logger.

Figures 29-31 and 35-37 plot only the average current densities within the matched current density cells, while Figures 32-34 and 38-40 plot only the average electric field intensities within the matched electric field cells. Within a cell, the electric field and current density coexist and are directly related via the cell conductivity. However, the control circuit design required to match one parameter precluded accurate measurement of the unmatched parameter with the data loggers because of very low voltage levels.

Figures 29 through 40 indicate that variations in the culture cell current densities and electric fields generally track the temporal variations in the earth electric fields that are used to drive the cells. Additional temporal variations in both the cell fields and currents may be the result of the cell conductivities changing with temperature and the growth of the amoeba colonies. The (matched) cell current densities are also a direct function of the cell fill levels, which may vary as the cells undergo biweekly subculturing.

The figures also indicate that, in general, the matched electric field intensities are more variable over time than are the matched current densities. This observation is consistent with differences in the two types of drive circuits employed to match the fields and currents. Matched current density cells are connected in series with a large resistance to limit cell current. As a result, any changes in the much smaller cell resistance that might be caused by changes in cell conductivity will have a negligible effect on the cell current and its density. On the other hand, the resistance in series with the matched electric field cells is on the same order as the cell resistance. Together they form part of a voltage divider network, which controls the cell voltage. In this case, a conductivity-related change in cell resistance will have a significant effect on the applied cell voltage, and hence on its electric field.

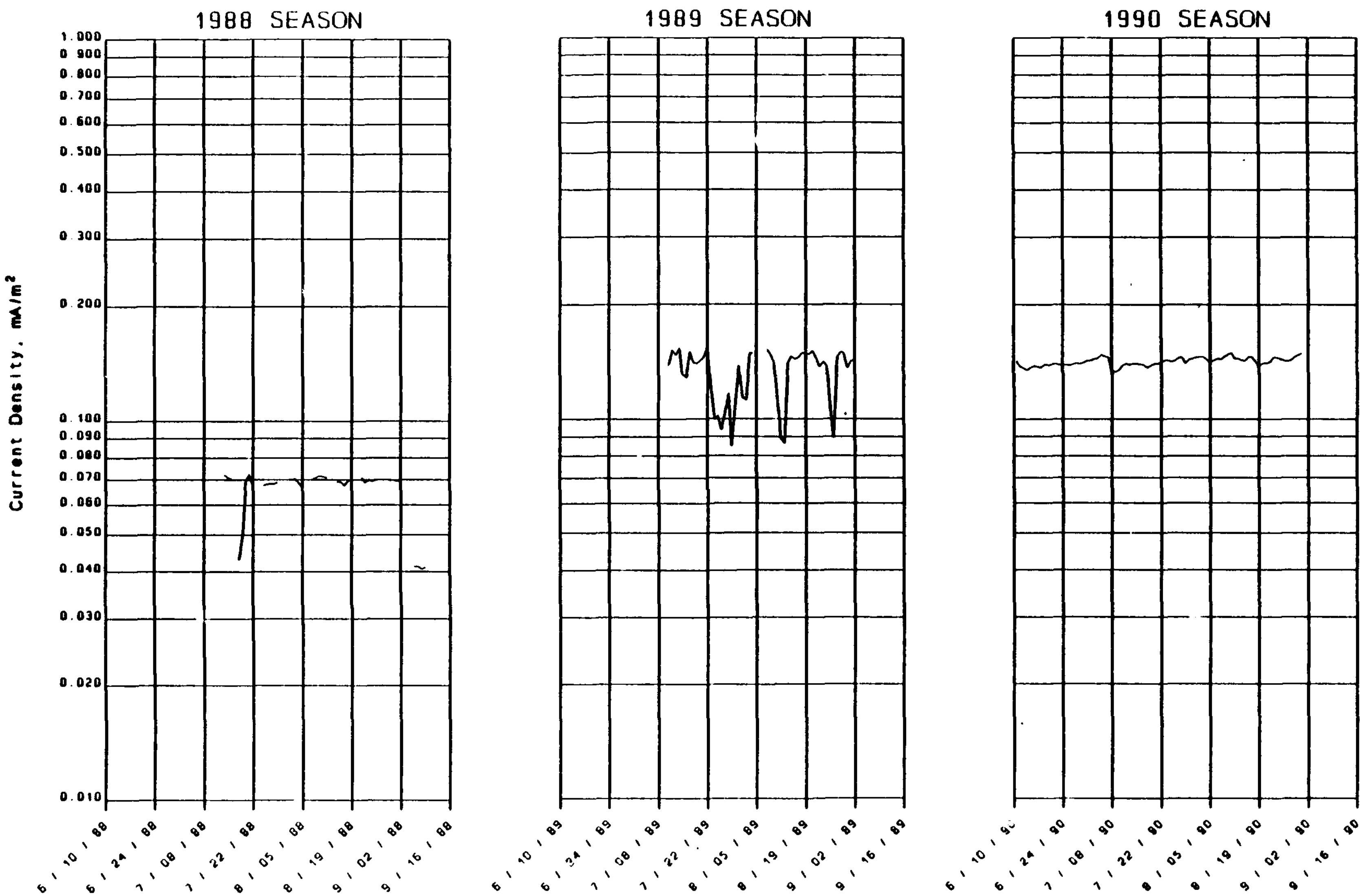



**FIGURE 29. DAILY AVERAGE CURRENT DENSITIES FOR CELL #1 AT THE SOIL AMOEBA ANTENNA STUDY SITE.**

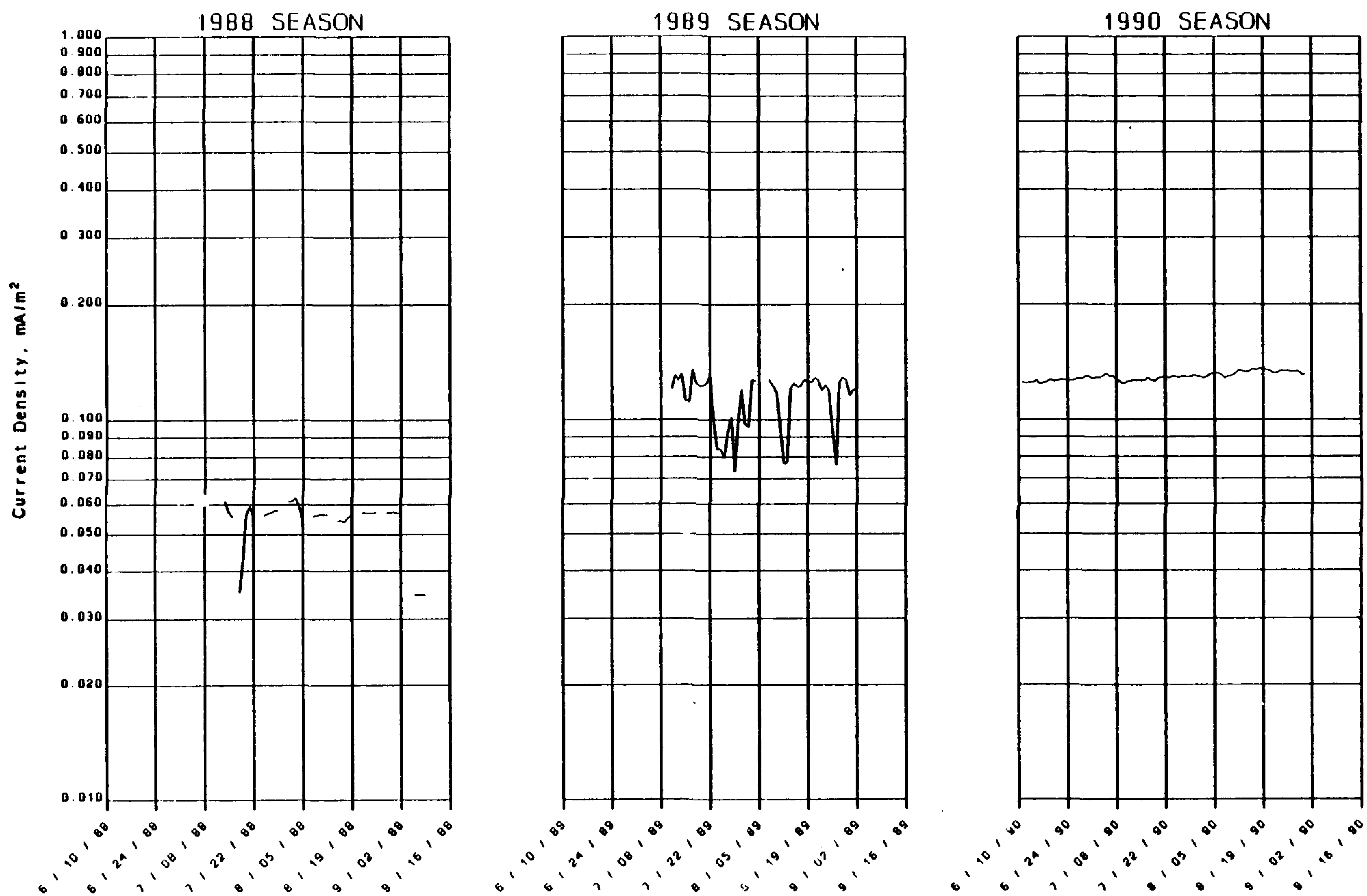



FIGURE 30. DAILY AVERAGE CURRENT DENSITIES FOR CELL #2 AT THE SOIL AMOEBA ANTENNA STUDY SITE.

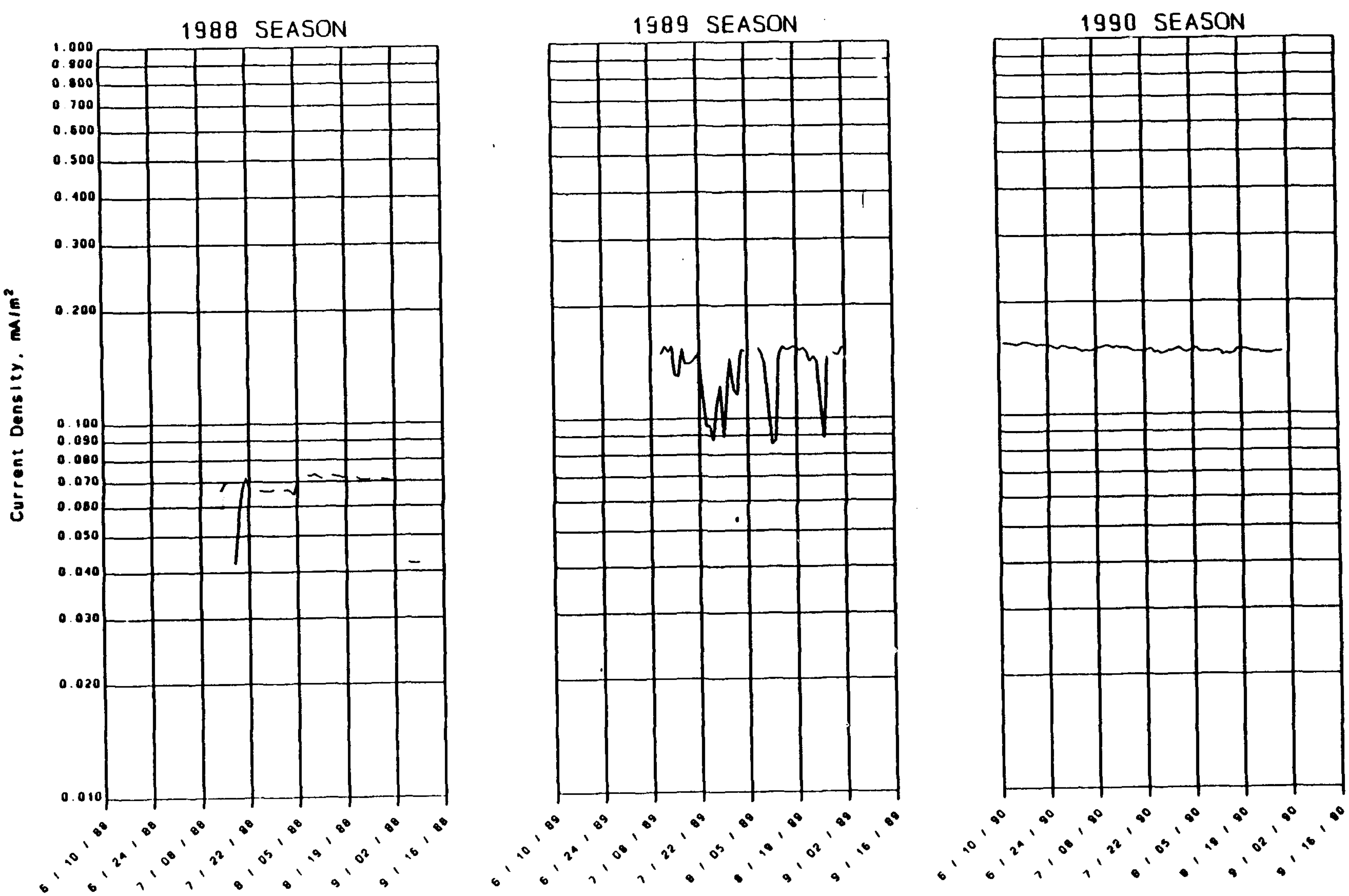



FIGURE 31. DAILY AVERAGE CURRENT DENSITIES FOR CELL #3 AT THE SOIL AMOEBA ANTENNA STUDY SITE.

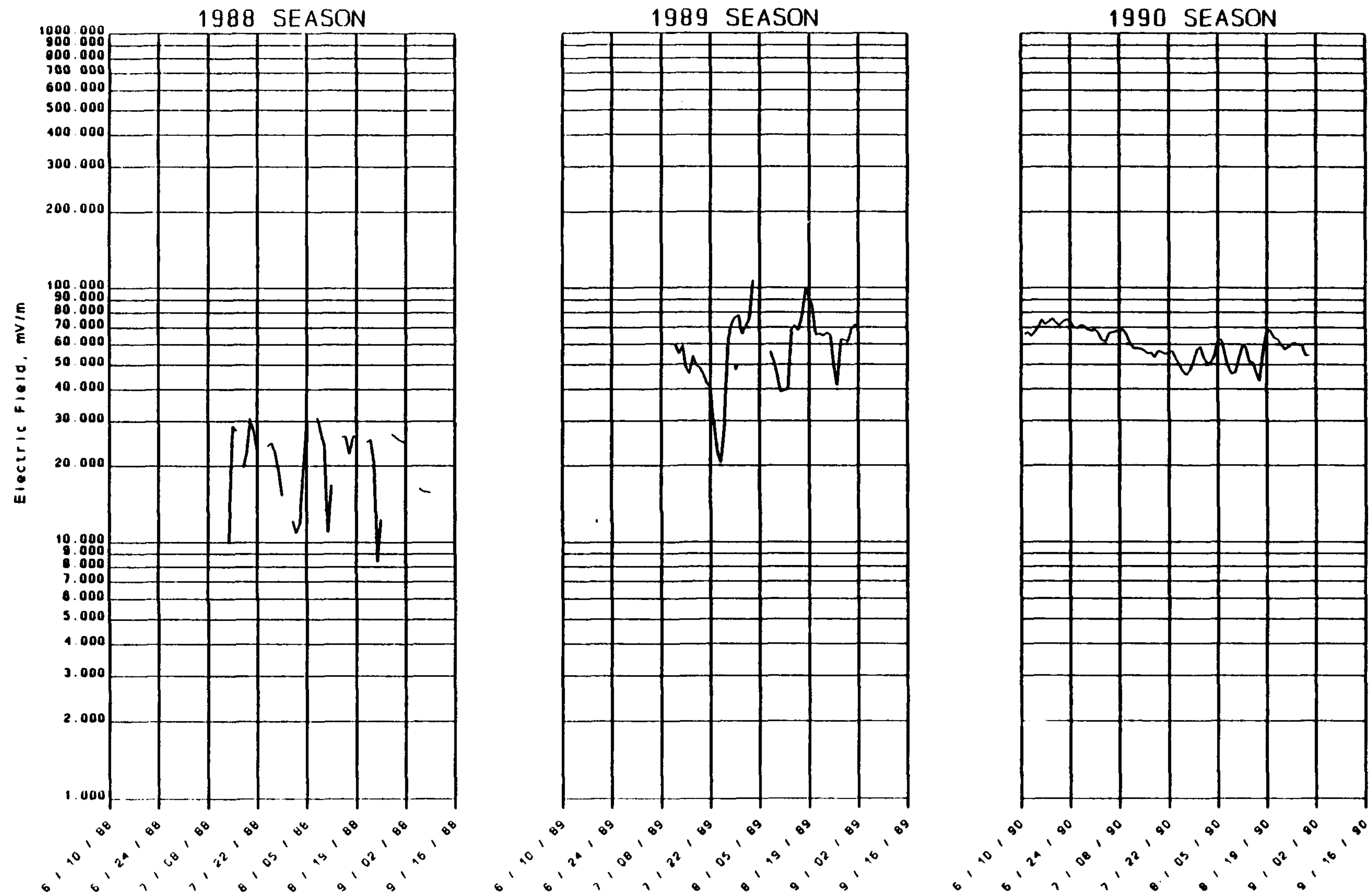



FIGURE 32. DAILY AVERAGE ELECTRIC FIELD INTENSITIES FOR CELL #4 AT THE SOIL AMOEBA ANTENNA STUDY SITE.

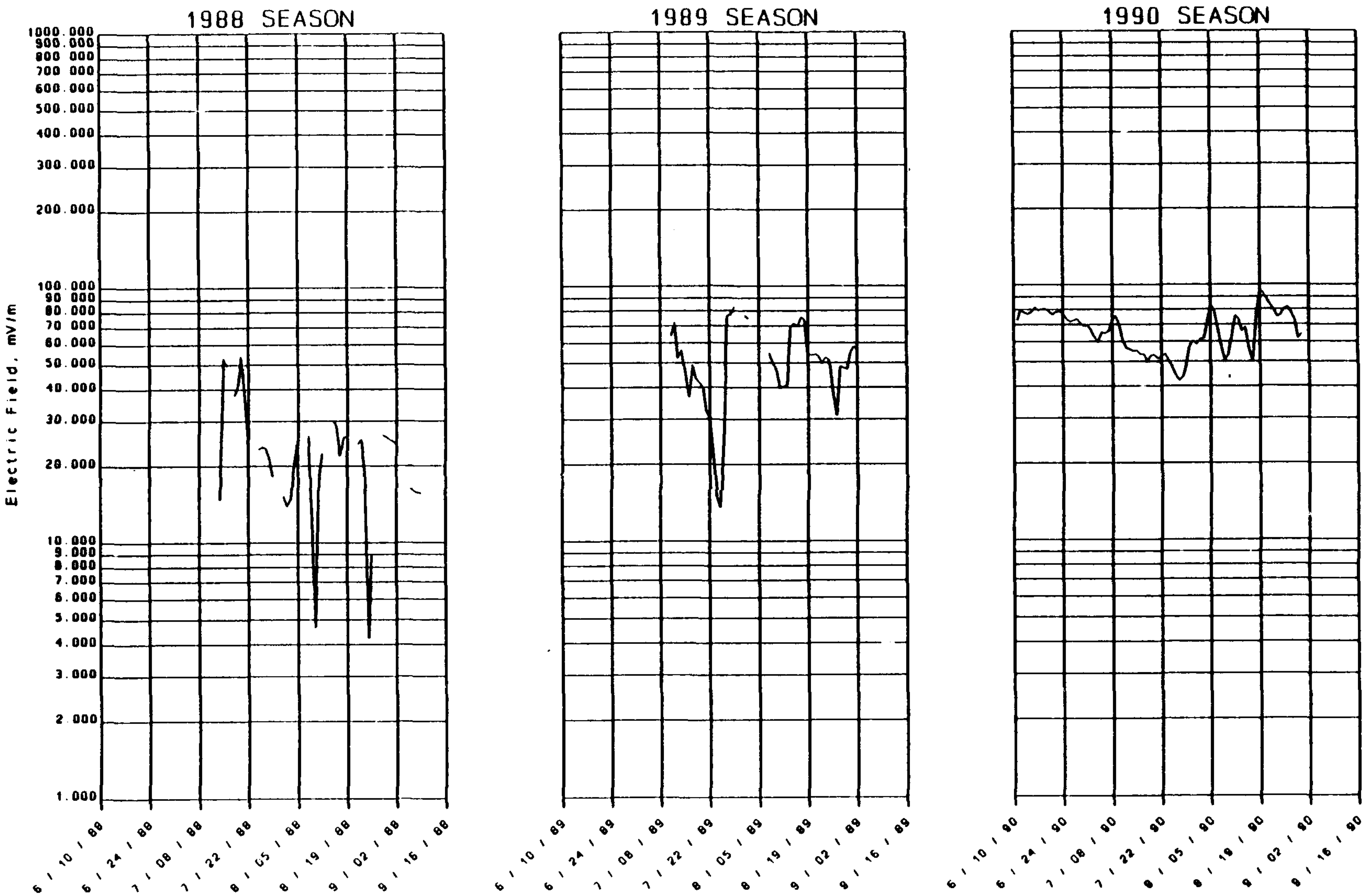



FIGURE 33. DAILY AVERAGE ELECTRIC FIELD INTENSITIES FOR CELL #5 AT THE SOIL AMOEBA ANTENNA STUDY SITE.

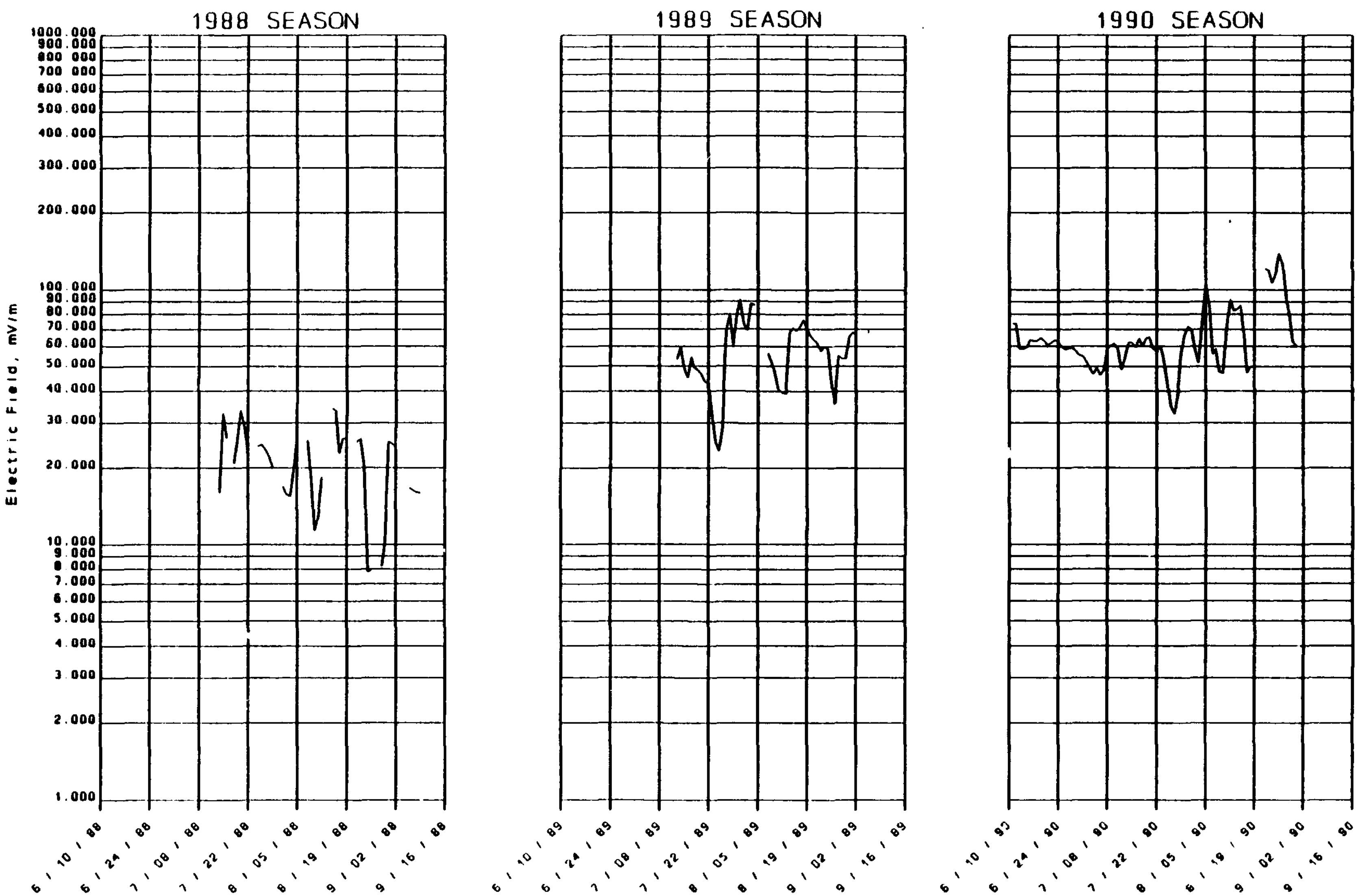



FIGURE 34. DAILY AVERAGE ELECTRIC FIELD INTENSITIES FOR CELL #6 AT THE SOIL AMOEBA ANTENNA STUDY SITE.

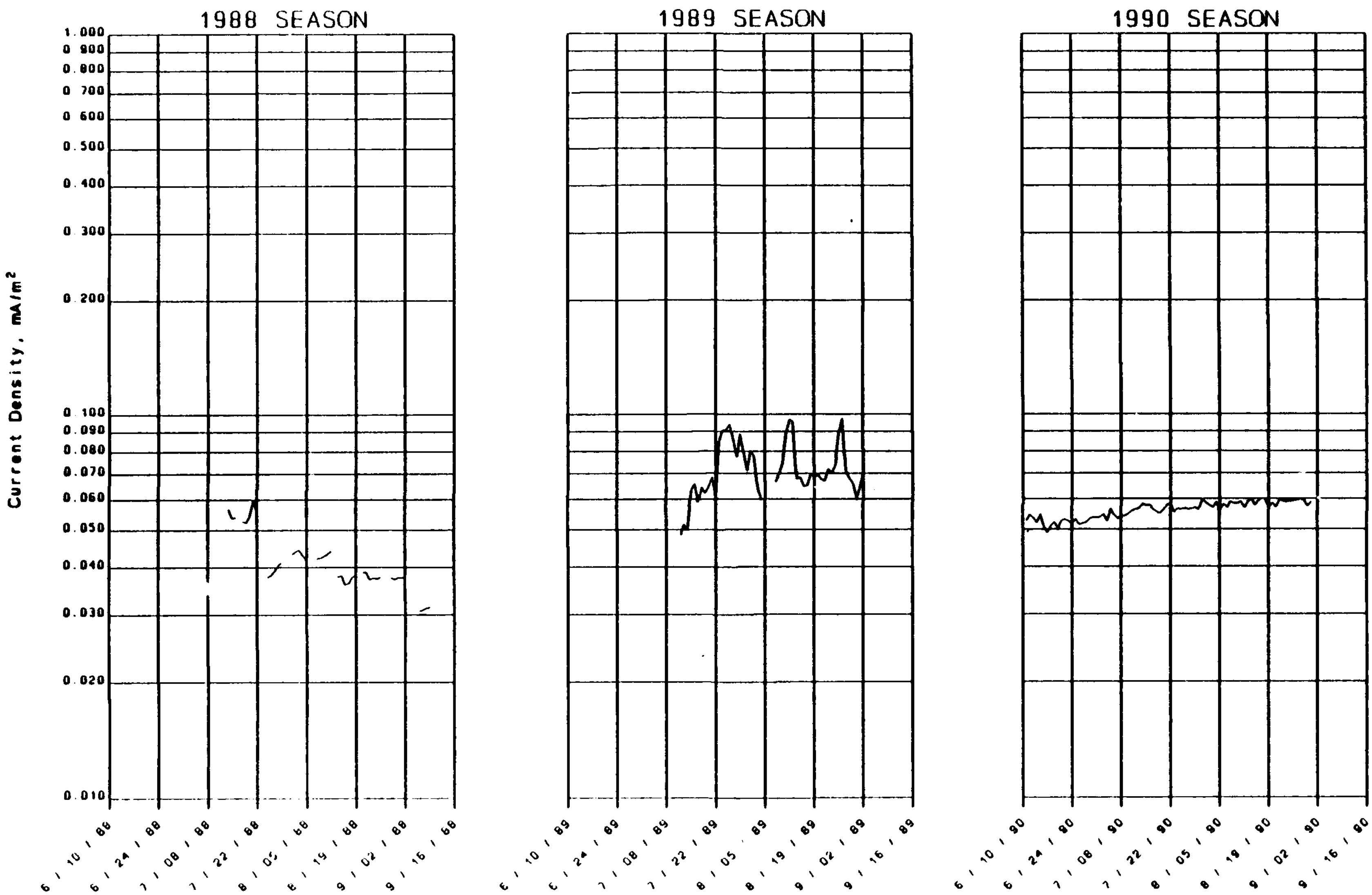



**FIGURE 35.** **DAILY AVERAGE CURRENT DENSITIES FOR CELL #1 AT THE SOIL AMOEBA GROUND STUDY SITE.**

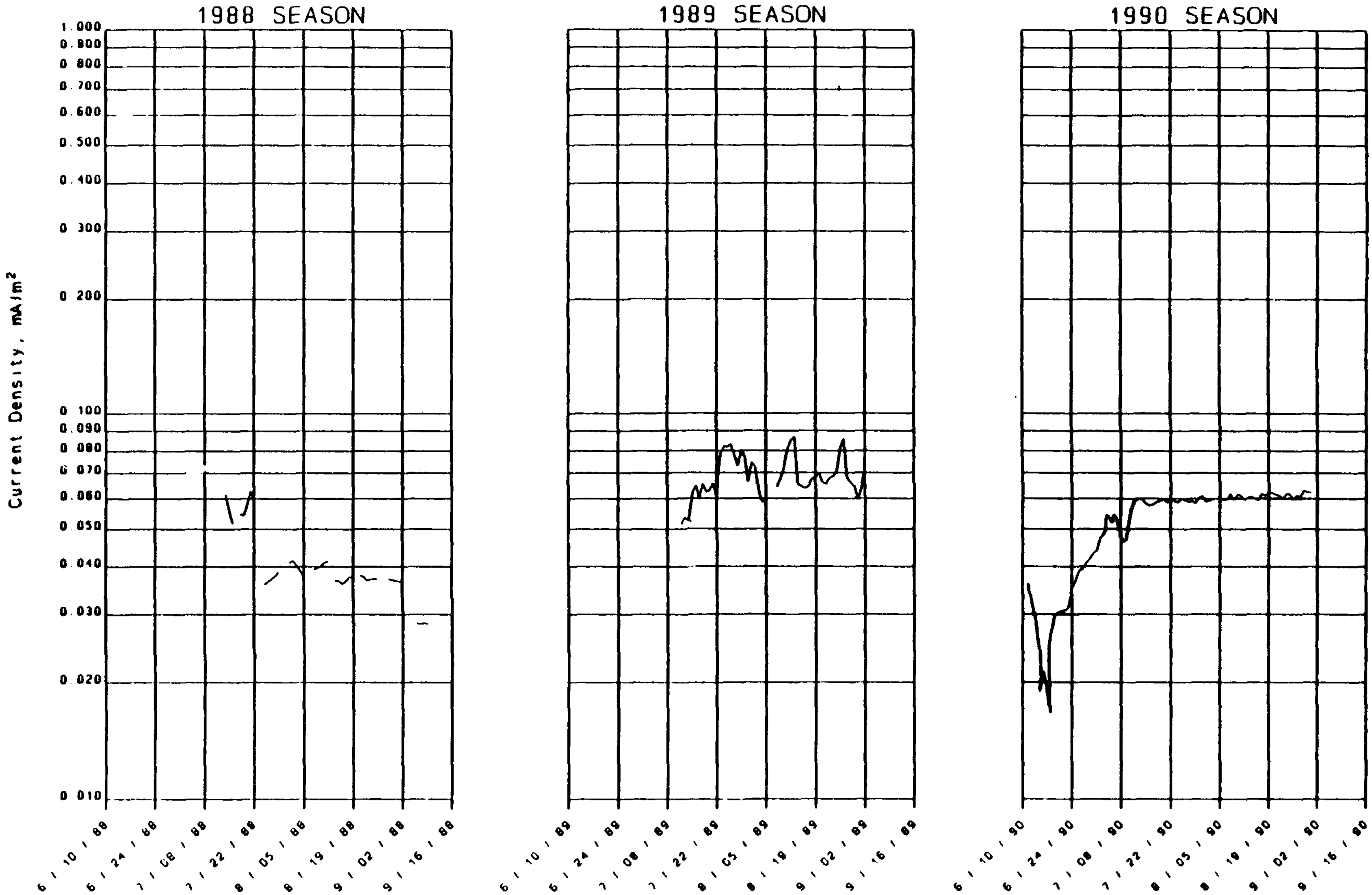



FIGURE 36. DAILY AVERAGE CURRENT DENSITIES FOR CELL #2 AT THE SOIL AMOEBA GROUND STUDY SITE.

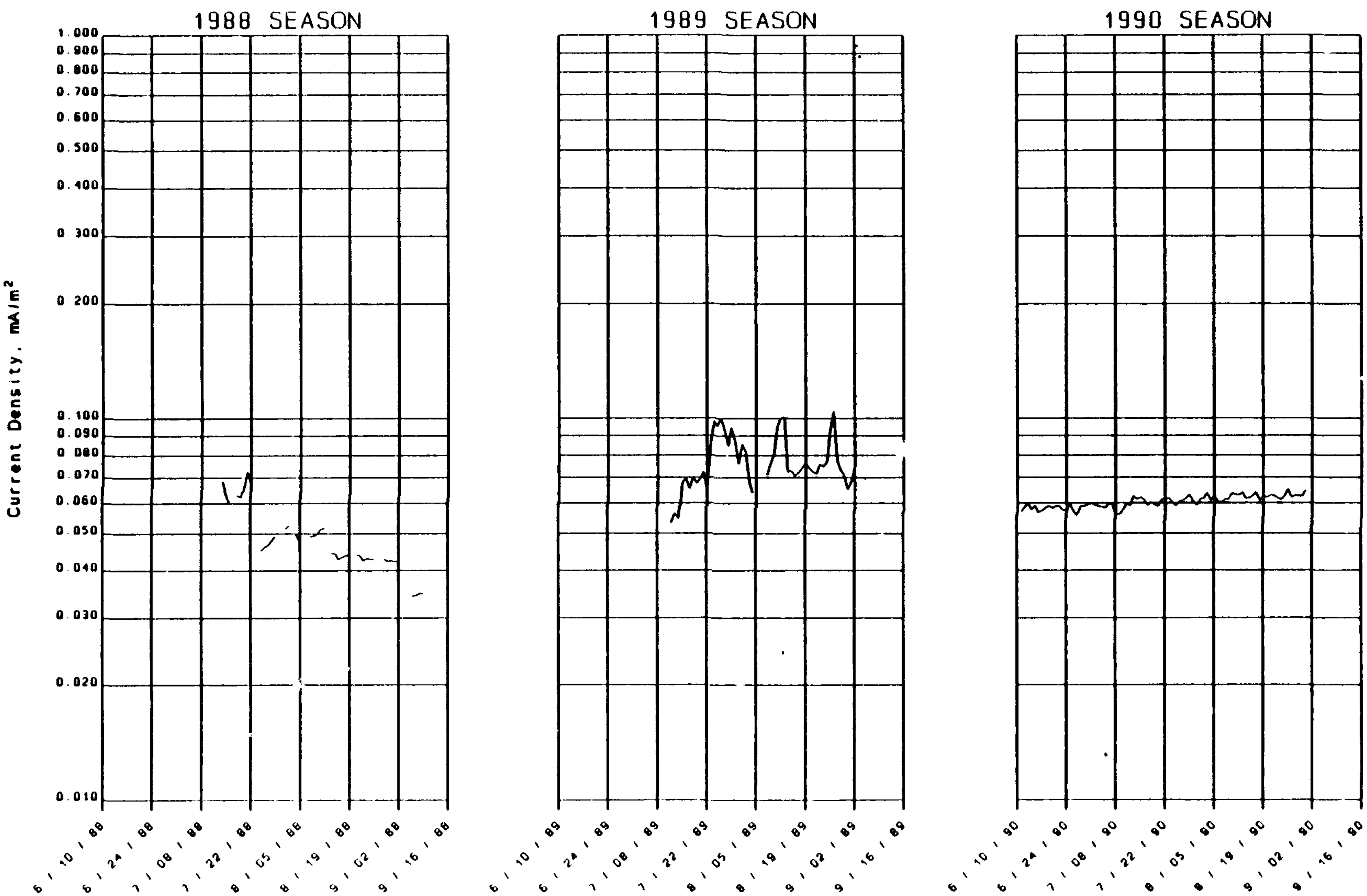



**FIGURE 37. DAILY AVERAGE CURRENT DENSITIES FOR CELL #3 AT THE SOIL AMOEBA GROUND STUDY SITE.**

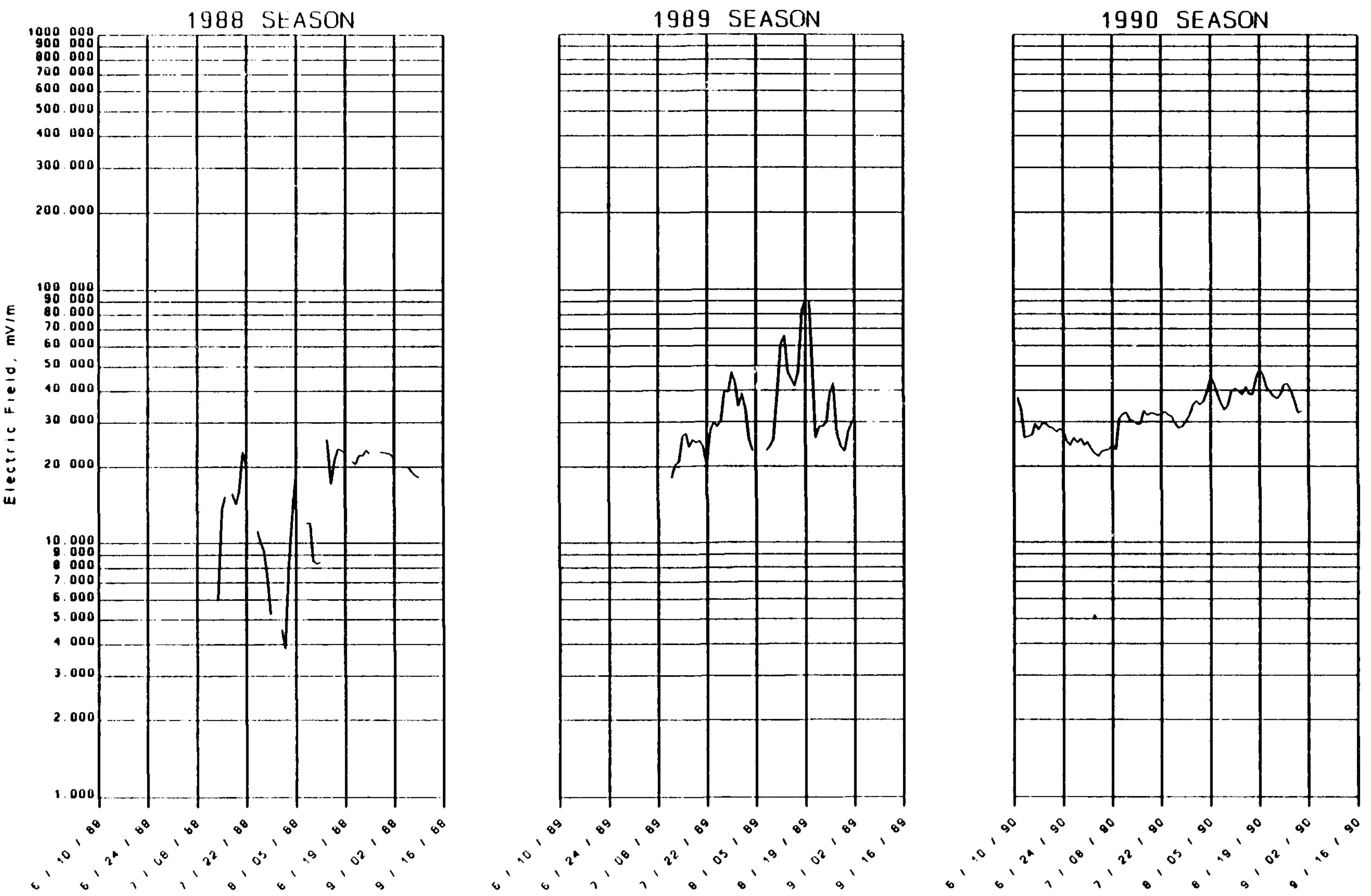



FIGURE 38. DAILY AVERAGE ELECTRIC FIELD INTENSITIES FOR CELL #4 AT THE SOIL AMOEBA GROUND STUDY SITE.

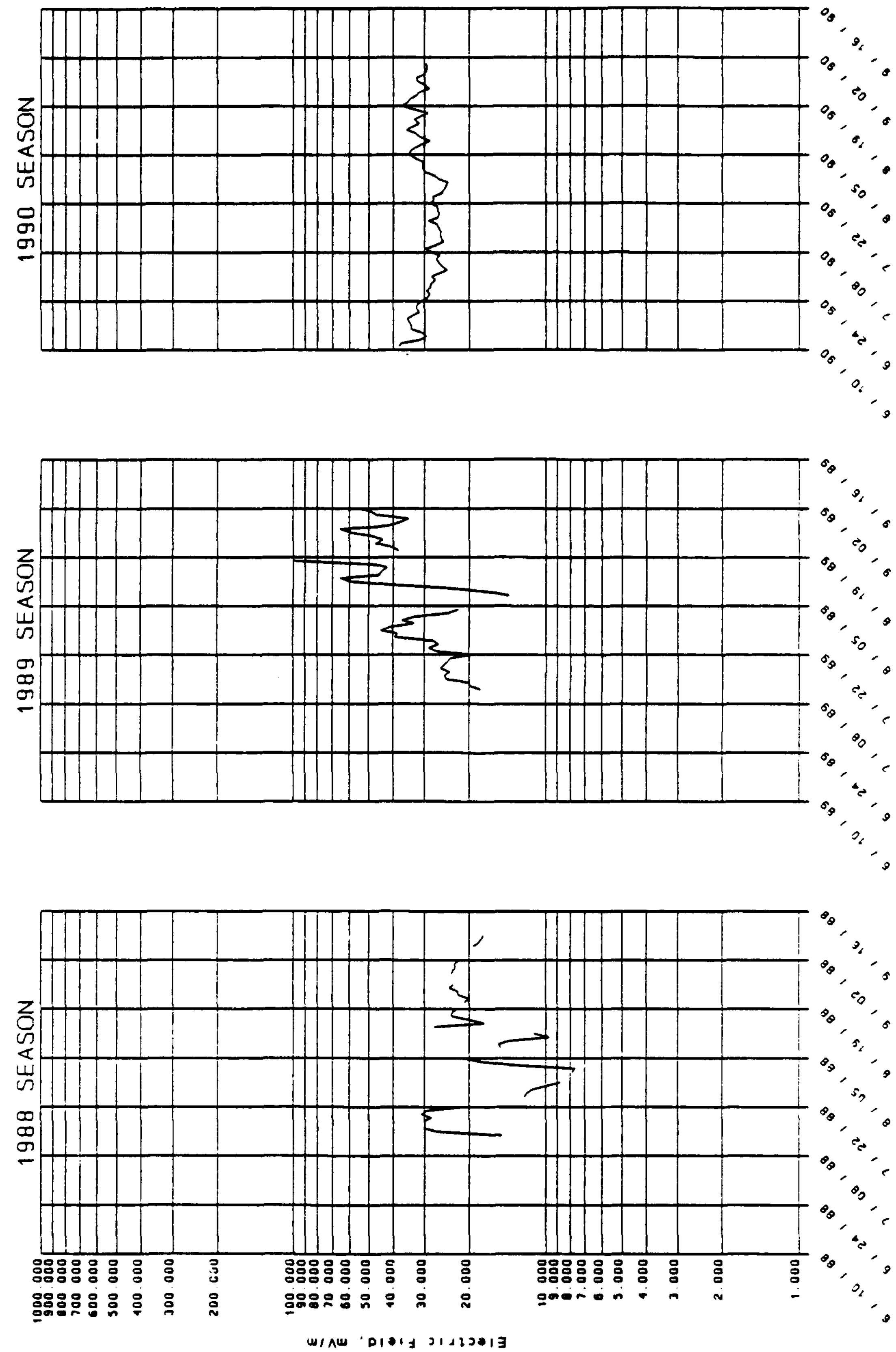



**FIGURE 39. DAILY AVERAGE ELECTRIC FIELD INTENSITIES FOR CELL #5 AT THE SOIL AMOEBA GROUND STUDY SITE.**

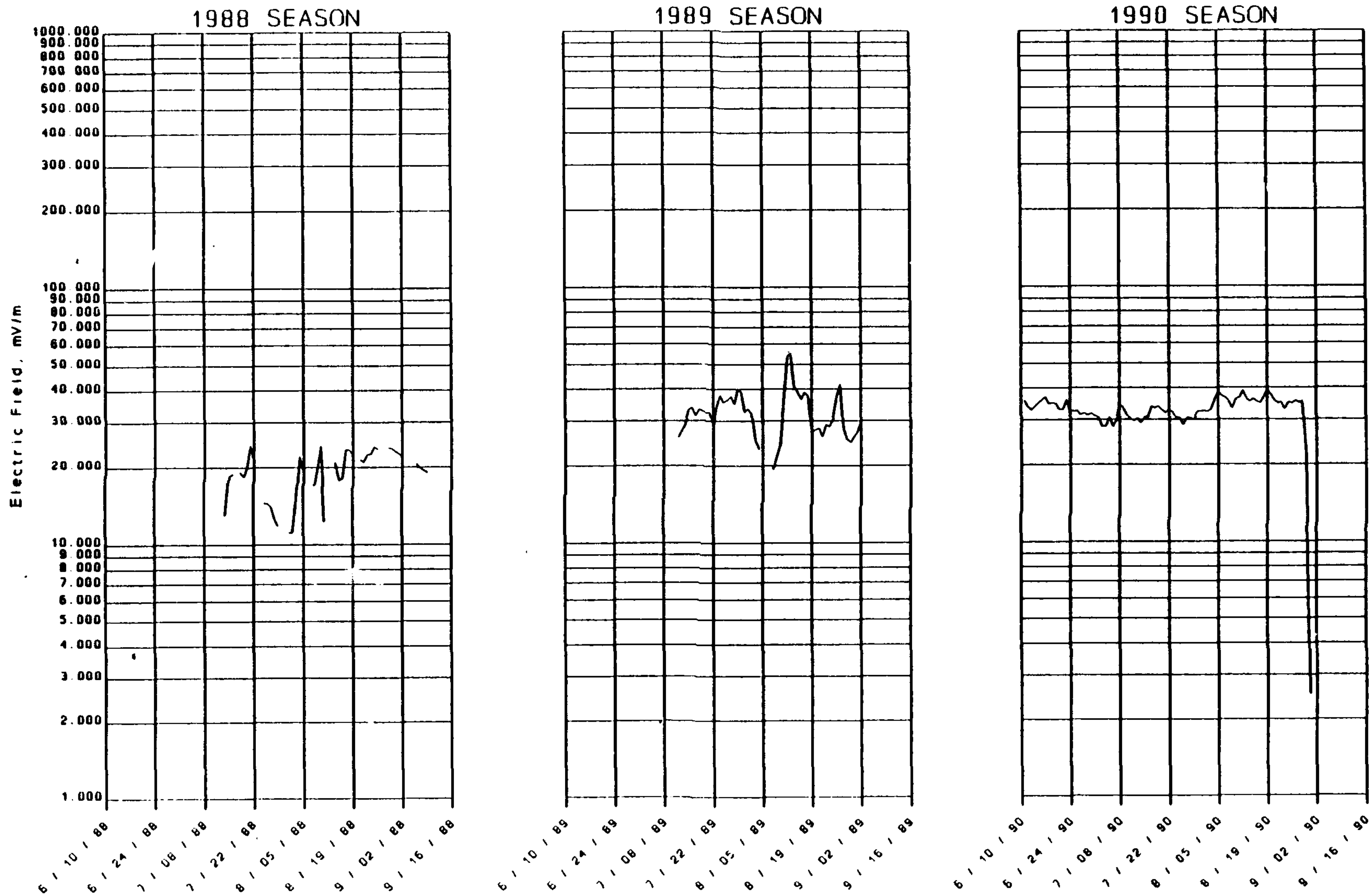



**FIGURE 40. DAILY AVERAGE ELECTRIC FIELD INTENSITIES FOR CELL #6 AT THE SOIL AMOEBA GROUND STUDY SITE.**

#### 4.3.6 Transmitter Operations--Analysis and Data Base

**4.3.6.1 Operating Log Data Base.** In order to calculate the EM exposure regimes, study investigators must have both field intensity measurements at the study sites and data on the operating times of the antennas. Field intensity measurements were discussed in Section 3, and data tables are presented in Appendixes A through G. Data on antenna operating conditions are provided to IITRI by the Navy's Submarine Communications Project Office. These data include changes in the operating frequency, modulation, power, and phasing for each antenna element. This information is entered into a computer-based spreadsheet that allows the generation of operating condition summaries in both graphic and tabular form. Graphic summaries for the NRTF-Republic are presented in this section; more detailed tabular summaries appear in Appendix J. IITRI provides the data bases to study investigators on request.

**4.3.6.2 Summary of NRTF-Republic Operations, 1986-1990.** The NRTF-Republic went through several stages of development. These stages are marked by changes in the operating times, currents, and configurations of the NRTF-Republic. The antennas or antenna elements at the NRTF-Republic were first operated in March 1986. A low-current (4, 6, or 10 amperes) unmodulated (continuous wave) signal was used, and the antennas or antenna elements were operated individually. In 1987, the antenna currents were increased to 15 amperes, and the NEW and SEW antenna elements were operated in parallel, constituting the EW antenna. Antenna currents were increased to 75 amperes during 1988. In May 1989, currents were increased to full power (150 amperes), the NS and EW antennas were operated simultaneously, and a modulated signal was used. Operating times increased dramatically as the NRTF-Republic entered its normal full-power operating mode in the latter half of 1989. Normal full-power operation continued throughout 1990.

During the 15- and 75-ampere testing periods in 1987, 1988, and 1989, virtually all transmitter operations were conducted according to a 15-minute rotational schedule commencing on the hour. Each cycle consisted of the following:

- 5 minutes--both antennas off
- 5 minutes--NS antenna only on
- 5 minutes--EW antenna only on

NRTF-Republic operational logs supplied to IITRI list specific times at which such cycles begin and end. The actual operating times were estimated by assuming a 33% duty cycle for each antenna during the testing period. The rotational schedule was not used after 150-ampere testing began in May 1989.

Figures 41 and 42 show the hours of operation for each antenna or antenna element on a month-by-month basis. The hours of operation for 1986 are shown separately in Figure 41 because the NEW and SEW antenna elements were operated individually in 1986, rather than in parallel as in following

years. Figure 43 provides a bar graph of the annual operating summary of the NRTF-Republic by mode of operation for 1987-1990. As can be seen, the predominant operating frequency was 76 Hz, although considerable testing was also performed at a 44 Hz frequency. The operating signal was normally unmodulated in 1987 and 1988, but predominantly modulated in 1989 and 1990, as it will be in the future. In 1986, which does not appear in Figure 43, essentially all operation was with a 76 Hz unmodulated signal.

The pie charts in Figure 44 provide an annual operating summary by percentage of time per antenna or antenna element for 1986-1990. In 1986, the total "on" time was 1.5%; this time was split about evenly among the NS antenna and the NEW and SEW antenna elements. In 1987, the total "on" time was 4.5%; this time was split evenly between the NS and EW antennas. In 1988, the total "on" time was 11.6%; this time was split evenly between the NS and EW antennas. In 1989, the total "on" time was 58%; both the NS and EW antennas operated simultaneously for the majority (91.8%) of this "on" time. In 1990, the total "on" time was 93.5%; both the NS and EW antennas operated simultaneously for the majority (95.2%) of this "on" time.

NRTF-Republic operations in 1986-1990 can be summarized as follows:

<u>1986</u>

- The NRTF-Republic was transmitting about 1.5% of the time (about 160 hr) (see Figures 41 and 44).
- About 98% of "on" time was with a continuous wave 76 Hz signal.
- The NS antenna and the NEW and SEW antenna elements were operated individually.
- Primary operating currents were 4 and 6 amperes for the NS antenna and the NEW antenna element, respectively, and both 6 and 10 amperes for the SEW antenna element.

<u>1987</u>

- The NRTF-Republic was transmitting about 4.5% of the time (about 400 hr) (see Figures 42 and 44).
- 100% of "on" time was with a continuous wave 76 Hz signal.
- The NS and EW antennas were operated individually.
- 99.6% of the operating time was with a 15 ampere current.

<u>1988</u>

- The NRTF-Republic was transmitting about 11.6% of the time (about 1000 hr) (see Figures 42 and 44).
- About 98% of "on" time was with a continuous wave 76 Hz or 44 Hz signal.
- The NS and EW antennas were operated individually.
- Primary operating currents were 15 and 75 amperes. 40.6% of "on" time was at 15 amperes, and 59.2% of "on" time was at 75 amperes.

1989

- The NRTF-Republic was transmitting about 58% of the time (about 5100 hr) (see Figures 42 and 44).
- About 57% of "on" time was with a modulated 76 Hz signal, and 28% of "on" time was with an unmodulated 76 Hz signal (see Figure 43).
- The NS and EW antennas were operated simultaneously for 91.8% of the "on" time.
- Primary operating currents were 75 and 150 amperes. 95% of "on" time was at 150 amperes.

1990

- The NRTF-Republic was transmitting about 93.5% of the time (about 8200 hr) (see Figures 42 and 44).
- About 95% of "on" time was with a modulated 76 Hz signal and both antennas operating simultaneously (see Figure 43).
- The NS and EW antennas were operated simultaneously for 95.2% of the "on" time.
- All operations were at 150 amperes.

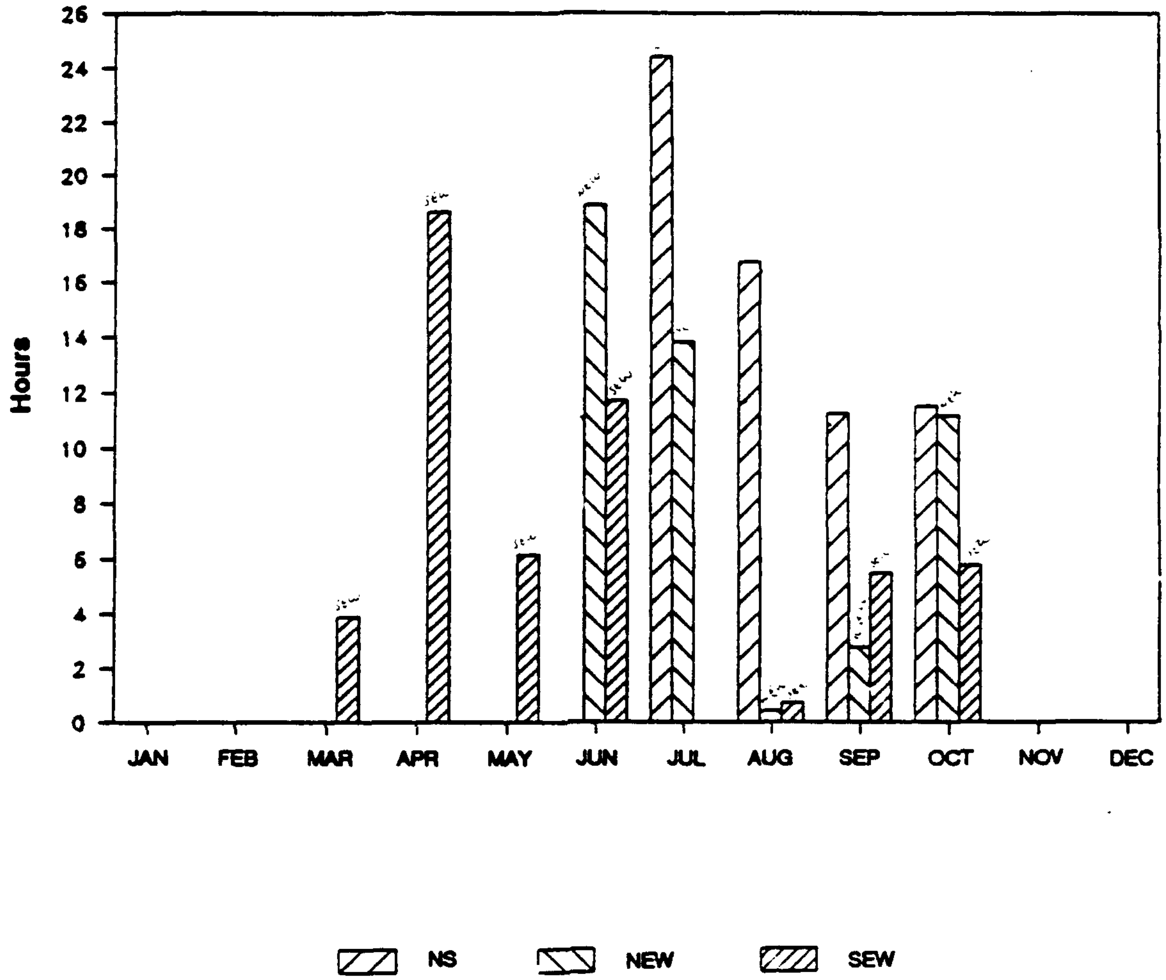



FIGURE 41. NRTF-REPUBLIC MONTHLY OPERATING SUMMARY, 1986.

60297/790

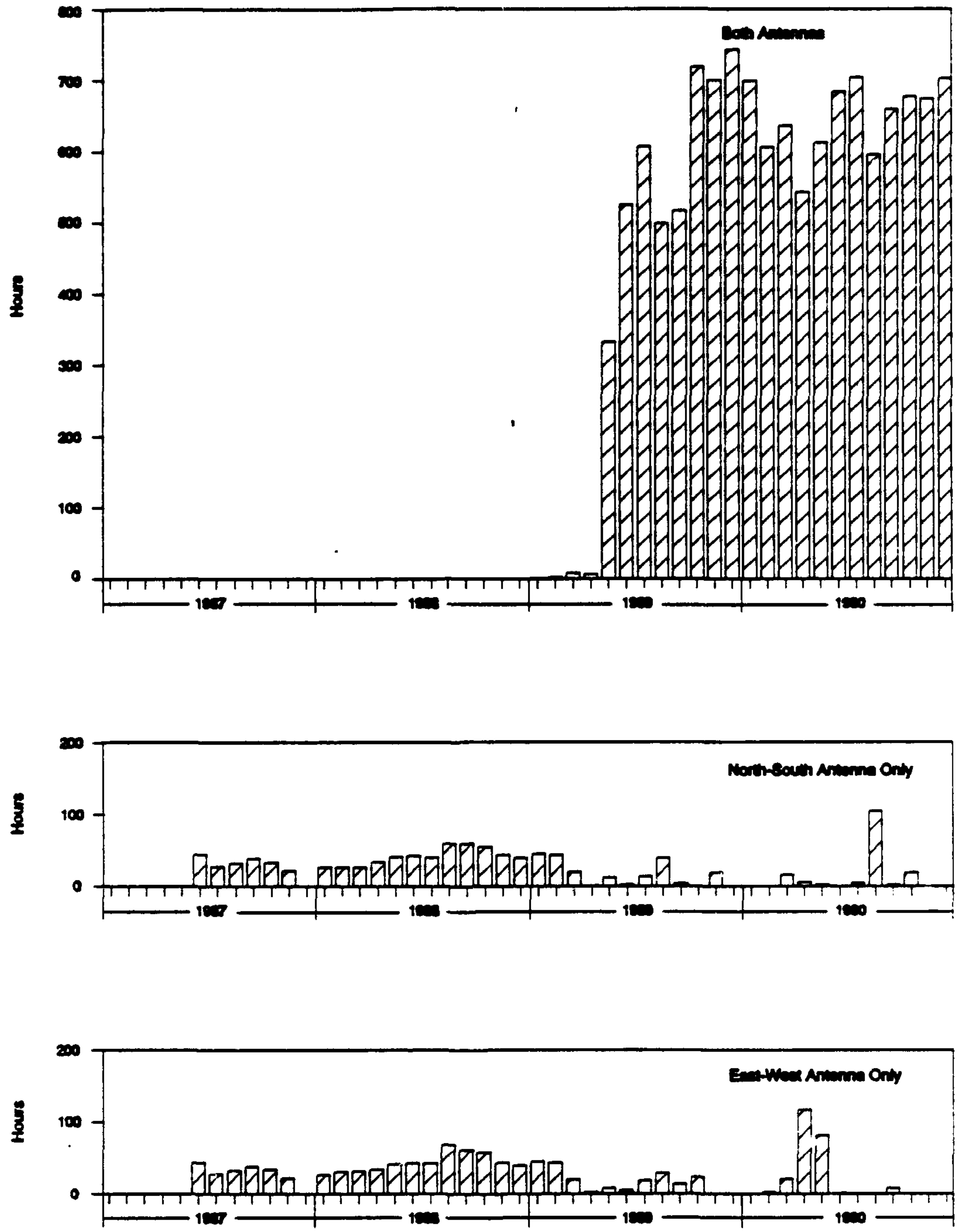



FIGURE 42. NRTF-REPUBLIC OPERATING SUMMARY, 1987-1990.

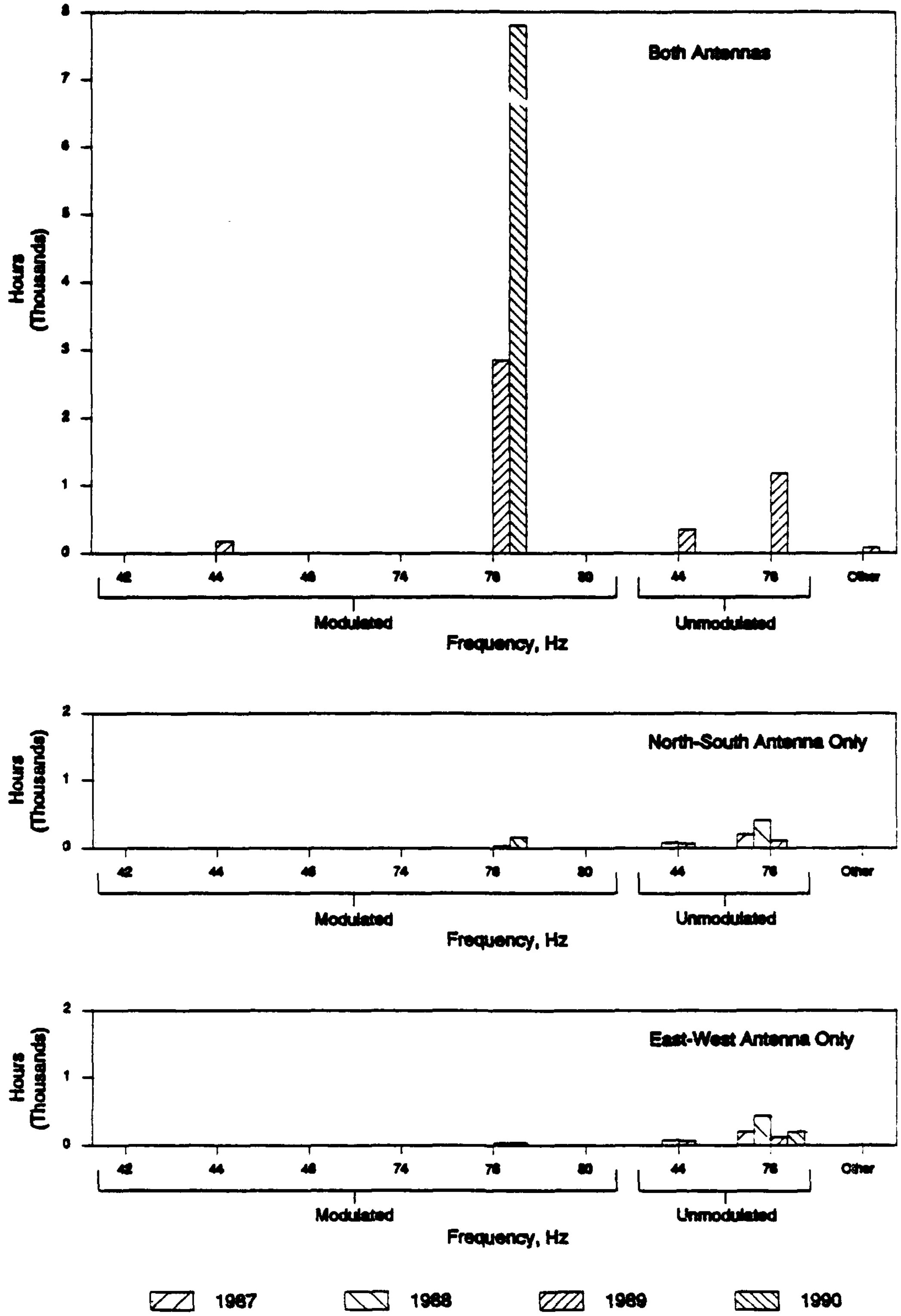



**FIGURE 43. NRTF-REPUBLIC OPERATING MODE SUMMARY, 1987-1990.**

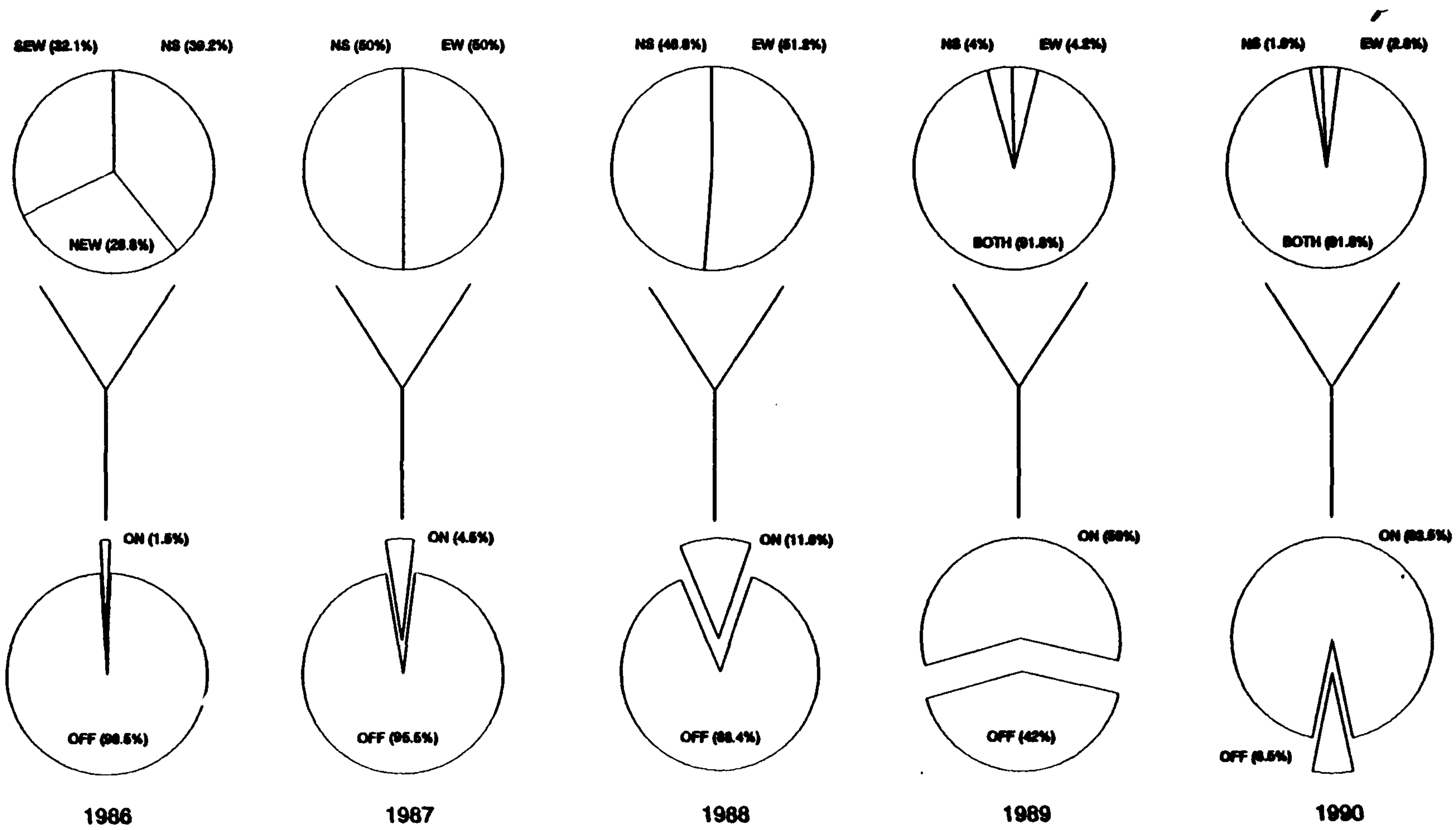



FIGURE 44. NRTF-REPUBLIC OPERATING SUMMARY: PERCENTAGE OF TIME PER ANTENNA ELEMENT, 1986-1990.

## 5. CONCLUSIONS AND DISCUSSION

Annual EM field measurement surveys in support of the Ecological Monitoring Program were performed during January, May, June, August, September, and October of 1990. Measurements were made at a total of 202 points at 50 study sites, compared with 196 points at 50 sites in 1989. New measurement points in 1990 include one at the laboratory of the small mammals and nesting birds studies, three at the laboratory of the native bees studies, five at the upland flora and soil microflora treatment study sites, and six at the aquatic ecosystems study sites. Points were added in order to test EM field mitigation in laboratories, better characterize spatial EM field variability at treatment sites, and test new study activity locations for improved treatment/control EM field ratios.

The NRTF-Republic continued operation with a 76 Hz, 150 ampere antenna current during 1990 using an MSK signal 95% of the time. 76 Hz EM field measurements were made at all points under modulated (MSK) transmission. Measurements were made of the ambient 60 Hz EM fields at treatment study sites only if both antennas were off since 60 Hz EM fields cannot be measured at treatment sites during modulated signal operation of the NRTF-Republic. At the control study sites, 60 Hz measurements were made regardless of antenna condition.

At the laboratory of the small mammals and nesting birds studies, the 60 Hz air electric fields and magnetic fields were found to be high relative to the EM fields at the study sites. Measures were taken to reduce the air electric fields by shielding and by equipment grounding. Magnetic fields at the metabolic testing bath, where they were the highest, were reduced with magnetic shields. These mitigation procedures reduced the air electric fields by factors of 4.5 to 20 and the magnetic fields by factors of 30 to 68. At the laboratory of the native bees studies, the 60 Hz air electric fields at work areas were also high relative to the EM fields at the study sites. Wire-mesh Faraday shield cages were built and installed at principal work areas and at a holding area. Measurements showed these shields to be effective in reducing the air electric fields by a factor of as much as 100.

Data loggers were designed, fabricated, and installed at the soil amoeba study sites in July 1988. The data loggers record electrical exposure parameters of the culture cells as well as the earth electric fields, soil temperature, and rainfall at the study sites. Culture cell measurements document changes in cell exposures as the cultures grow and soil parameters change with moisture and temperature.

Seasonal variations of the earth electric field are of concern to study investigators whose biota remain on a study site throughout the year. The variations are being continuously monitored near both a ground terminal and an antenna ROW, using the data loggers set up for the soil amoeba studies. At the end of each biological field study season, the logger programs are changed to measure only the earth electric fields throughout the fall, winter, and spring months to provide information on the seasonal variability of the earth electric field. Data loggers have remained on the study sites since their installation

in 1988, except for a period in the first quarter of 1989 when they were removed for maintenance and modifications. Data collection using this equipment is expected to continue throughout the course of the study.

Researchers for the upland flora and soil microflora studies observed yearly differences in aspen growth rates at their antenna study sites. In order to test for a correlation between EM field exposures and aspen growth rates, the researchers requested detailed EM field intensity data so that exposures could be estimated for each tree on their plots. IITRI initially addressed this request by measuring field profiles at the treatment sites. Results showed the earth electric field to be very irregular at the antenna study site, making a single profile insufficient for accurately estimating earth electric field intensities over the entire plot. In 1990, a rigorous electric field survey was performed at the antenna and ground treatment study sites, and field contour maps were drawn and used for estimating earth electric fields over the entire plot. In addition, fixed electric field probes were established to determine temporal variations of this field at the treatment study sites. Measurements, made twice a month at the fixed probes, have shown little variation in these fields thus far. Data loggers will be installed at the treatment study sites in 1991 to provide a more detailed view of temporal variations in the earth electric field.

Ratios of 76 Hz EM fields were recalculated for the aquatic ecosystems treatment and control study site pairs using the newly obtained 150 ampere measurement data. As predicted early in the study, not all of the study site pairs met the guidelines discussed in Section 1.3 of this report. Refinements were made of activity locations within study sites, and 1990 measurements verified improvement in the ratios of prime concern through the use of these new locations. A fyke net was added between the NS antenna and a 138 kV transmission line for the fish movement studies. This will allow discrimination between possible effects from these two EM field sources on fish movement behavior.

Variations of the longitudinal electric field intensities and magnetic flux densities along the centerlines of treatment transects for the bird species and communities studies in Michigan were characterized by making several measurements along the length of each transect. The magnetic flux density showed little variation, with the exception of two points where the separation between the transect and antenna decreases. The earth electric field was more variable than the magnetic flux density, due to variations in the local soil conductivity.

In 1991, the NRTF-Republic is expected to operate both antennas simultaneously with a 150 ampere MSK signal, as it did during 1990. IITRI plans to remeasure all points characterized in 1990. Measurement protocols to be used in 1991 will be determined by the actual antenna status at the time, although they are not expected to differ from those used in 1990.

## 6. REFERENCES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10. ELF Communications System Ecological Monitoring Program: Wisconsin Bird Studies–Final Report. IIT Research Institute, Technical Report E06628-2, February 1991, 99 pp.

# APPENDIX A

## SMALL MAMMALS AND NESTING BIRDS STUDIES

## SMALL MAMMALS AND NESTING BIRDS STUDIES

These studies monitor parental care, nestling growth and maturation, fecundity, homing, activity patterns, embryological development, and metabolic physiology of small mammals and nesting birds. The electric and magnetic fields in the air are considered important factors to be examined in orientation and other behavior patterns of birds. The electric and magnetic fields in the earth and near its surface are important to the small mammals studies. The air electric field and magnetic field in the laboratory where study animals undergo physiological testing, and in the holding areas used prior to these tests, are also of importance.

IITRI field crews made ELF electromagnetic (EM) field measurements at 71 measurement points within the five treatment sites, four control sites, three (bird) displacement sites, the Crystal Falls laboratory site, and the remote holding facility for the small mammals and nesting birds studies in 1990. The measurement regime differed from 1989 in that one measurement point (1L1-10) was added and one measurement point (1L1-3) was re-established to assess the 60 Hz EM exposures at the Crystal Falls laboratory site. Measurement dates for 1990 and previous years appear in Table A-1.

**TABLE A-1. EM FIELD MEASUREMENT DATES**
**Small Mammals and Nesting Birds Studies**

| Year | Measurement Dates | | |
|---|---|---|---|
| 1983 | May 23, 24, 26 | Jun 9, 14, 15 | Jul 13, 14 |
| 1984 | May 16, 17 | Aug 6, 7, 9, 10, 14-16, 21, 22 | |
| 1985 | Jul 15, 17, 18, 22-24 | | |
| 1986 | Oct 2, 3, 6, 8, 14-17 | | |
| 1987 | Sep 24, 28-30 | Oct 1, 5, 6, 8 | Dec 11 |
| 1988 | Sep 19-22, 27, 28 | Oct 3-5 | Nov 11 |
| 1989 | Feb 21 | Sep 13-15, 18, 20-22 | Oct 12 |
| 1990 | Jan 9, 10, 22 | Sep 24, 25, 27 | Oct 2, 4, 8-10 |

The positions of all sites relative to the NRTF-Republic are shown on the composite map in Figure A-1. The site numbers listed on the map are those used by IITRI. Table A-2 provides a cross-reference of IITRI site numbers, investigator site names, and township, range, and section numbers for the sites. Details of measurement locations within sites are shown in Figures A-2 through A-16.

EM field measurements for 1990 and previous years are found in Tables A-3 through A-8. Tables A-3, A-4, and A-5 present 60 Hz data for the air electric field, earth electric field, and magnetic flux density,

**TABLE A-2. SITE NO. CROSS-REFERENCE**
**Small Mammals and Nesting Birds Studies**

| IITRI Site No. | Investigator's Site Name | Location Township | : | Range | : | Section(s) |
|---|---|---|---|---|---|---|
| 1T1 | Pirlot Road | T43N | : | R29W | : | 23, 26 |
| 1T2 | Cleveland Homestead | T44N | : | R29W | : | 25 |
| 1T4 | North Turner Road | T43N | : | R29W | : | 1 |
| 1T5 | Ford River North | T43N | : | R29W | : | 14 |
| 1T6 | Ford River South | T43N | : | R29W | : | 14 |
| 1C1 | Michigamme North | T44N | : | R31W | : | 13 |
| 1C3 | Michigamme South | T44N | : | R31W | : | 24 |
| 1C4 | Panola Plains | T42N | : | R32W | : | 10 |
| 1C6 | Tachycineta Meadow | T42N | : | R31W | : | 3 |
| 1D1 | Cleveland Homestead Displacement | T47N | : | R28W | : | 36 |
| 1D2 | North Turner Displacement | T46N | : | R28W | : | 12 |
| 1D3 | Panola Plains Displacement | T4[illegible]N | : | R31W | : | 14 |
| 1L1 | Crystal Falls Laboratory | T43N | : | R32W | : | 29 |
| 1L4 | Remote Holding Facility | T42N | : | R32W | : | 9 |

respectively. These tables include data for 18 measurement locations that are no longer active. This has been done in order to provide historical measurement values at study sites where new measurement locations were laid out after antenna construction in 1986. Tables A-6, A-7, and A-8 present 76 Hz data for these three fields as well as the corresponding operating currents of the NRTF-Republic for each year. 60 Hz data for the air electric field and magnetic flux density measured at the Crystal Falls laboratory from 1986 to 1990 appear in Tables A-9 and A-10.

Plots of the 60 Hz EM field profiles for the five nest box sites for the years 1987 through 1990 are presented in Figures A-17 through A-23. Considerable year-to-year variability in these fields is evident. The primary factors in this variability are changes in power line loading conditions (which are unknown) and differences in the configuration of the antennas at the time of measurement. Notes on the antenna configurations are included in the tables primarily for engineering use. The 60 Hz measurements in 1987, 1988, and 1990 were taken while the antennas were off, and are representative of 60 Hz levels present during maintenance periods. Some 1989 measurements were taken at the treatment sites during full-power operation of the

antennas with an unmodulated signal. These values indicate that 60 Hz EM fields present during operation of the antennas are comparable to those present when the antennas are off. It should be noted that a significant gradient in the 60 Hz fields exists across the nest box treatment sites because of their size and the 60 Hz coupling to the nearby NS antenna.

Annual variations in the 60 Hz fields measured at the control study sites are also caused by differences in power line loading, but are not dependent on the antennas or their configuration because of the distance of these sites from the antennas. The 60 Hz field values at the control sites show lower spatial variation compared to those at the treatment sites because the antenna is not present to establish a field gradient.

Overall, the 60 Hz EM fields measured at all of the study sites in 1990 are consistent with previous field values and with the expected differences in power line loads and antenna configuration. Regardless of the field variability associated with the measurement condition, 76 Hz EM fields at treatment sites consistently dominate the 60 Hz EM fields at treatment and control sites, and the ratios of 60 Hz EM fields between matched treatment/control sites continue to meet exposure criteria guidelines established at the beginning of the study.

The 76 Hz EM field measurements in 1990 were made with 150 ampere antenna currents, the predominant operating current of the NRTF-Republic since 4 May 1989. The antenna currents at which measurements were made in each year are shown in the column headings of Tables A-6 through A-8. The annual increases in field magnitudes reflect the level of antenna current at the time of measurement: 4 or 6 amperes in 1986, 15 amperes in 1987, 75 amperes in 1988, and 150 amperes in 1989 and 1990. The 1990 measurements are consistent with the 1989 measurements at the same current, and proportional in the 1986, 1987 and 1988 measurements made at lower currents.

Plots of the 76 Hz EM field profiles for the five nest box test sites for the years 1987 through 1990 are presented in Figures A-24 through A-37. The annual increases in field magnitudes illustrated by these profiles reflect the level of antenna current at the time of measurement: An estimate of the EM field levels for any nest box at a treatment site can be obtained graphically from Figures A-24 through A-37 given the perpendicular distance of the nest box from the antenna wire.

EM field measurements were made at the release points for the Cleveland Homestead, North Turner Road, and Panola Plains tree swallow homing transects. The EM field environment along the flight paths can be estimated using Figures A-38 and A-39, which show the locations of the bird flight paths and the ELF antenna relative to positions of high-voltage 60 Hz transmission lines and 60 Hz power distribution lines, respectively. The EM fields generated by the distribution lines are of magnitudes similar to those that are generated by the ELF antenna when it is operating at full power. The EM fields produced by the transmission lines can be considerably higher, depending on operating conditions. The air electric field generated by a transmission line may be as much as 100 times greater than that of the ELF antenna; the

magnetic flux generated by a transmission line is dependent on the load current, and may be several times greater than that of the ELF antenna.

The 60 Hz field intensities measured at the Crystal Falls laboratory in 1989 were nominally 100 times greater than those at the study sites, and were of the same order of magnitude as the 76 Hz intensities at the treatment sites. IITRI made efforts to reduce the ambient field levels in critical laboratory work areas by recommending methods for shielding sources of electric fields and by providing magnetic shielding for the containers used for metabolic testing.

Magnetic and air electric field shielding in the Crystal Falls laboratory was discussed in Section 4.1.1 of this report. Table A-9 presents 60 Hz air electric field data before and after shielding was implemented in the Crystal Falls laboratory. It can be seen from this table that the air electric field shielding reduced the fields by factors of 4.5 to 20.

Figure A-40 shows the locations of magnetic shields used to reduce the 60 Hz magnetic field exposures in the cooling bath during metabolic tests. The effectiveness of the shielding is seen in Table A-10, which gives the magnetic flux densities inside the test containers under three different shielding configurations. The final shielding configuration served to reduce the magnetic fields inside the test containers by factors of 30 to 68.

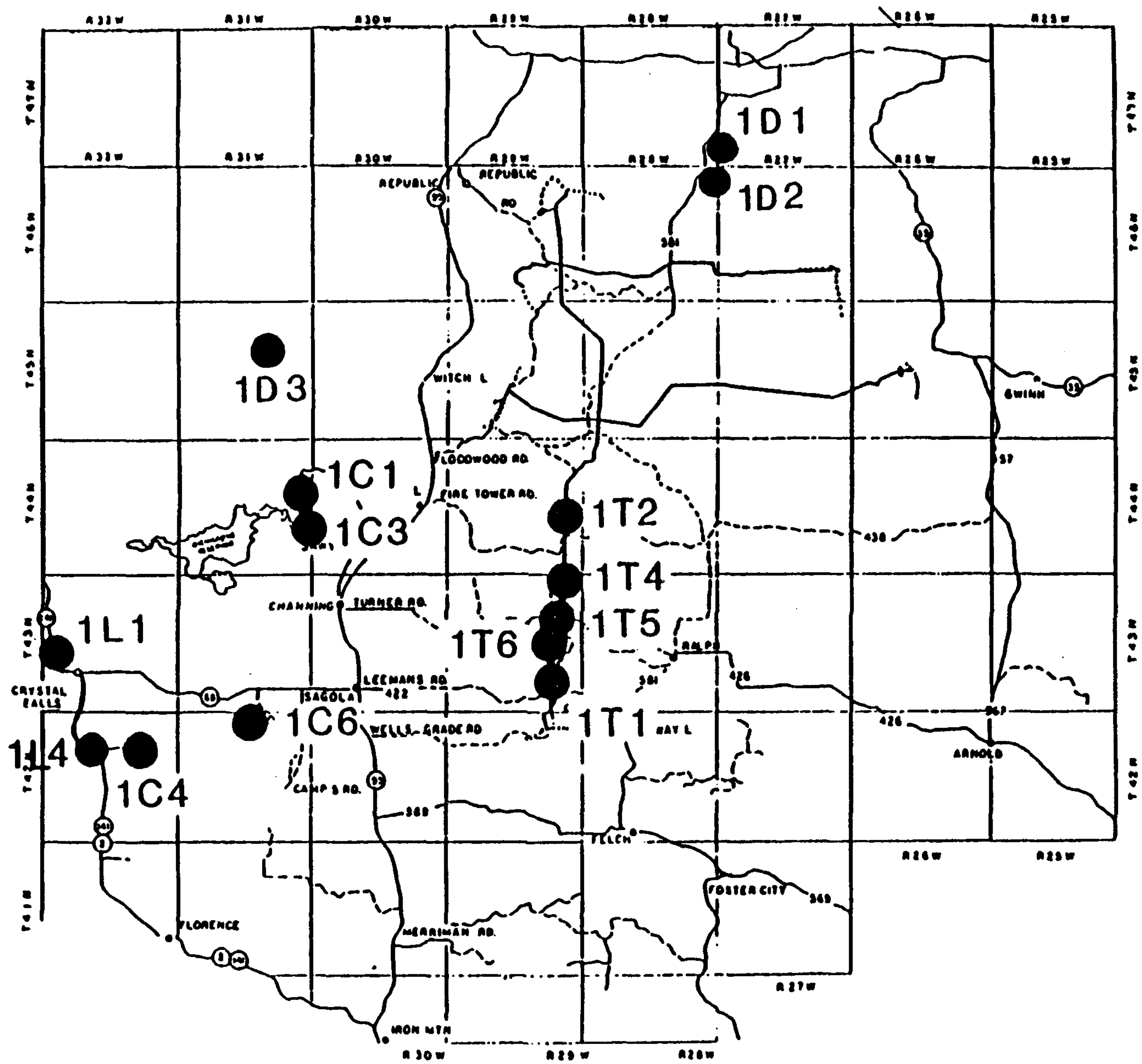



FIGURE A-1. POSITIONS OF SMALL MAMMALS AND NESTING BIRDS STUDY SITES RELATIVE TO NRTF-REPUBLIC ANTENNA ELEMENTS.

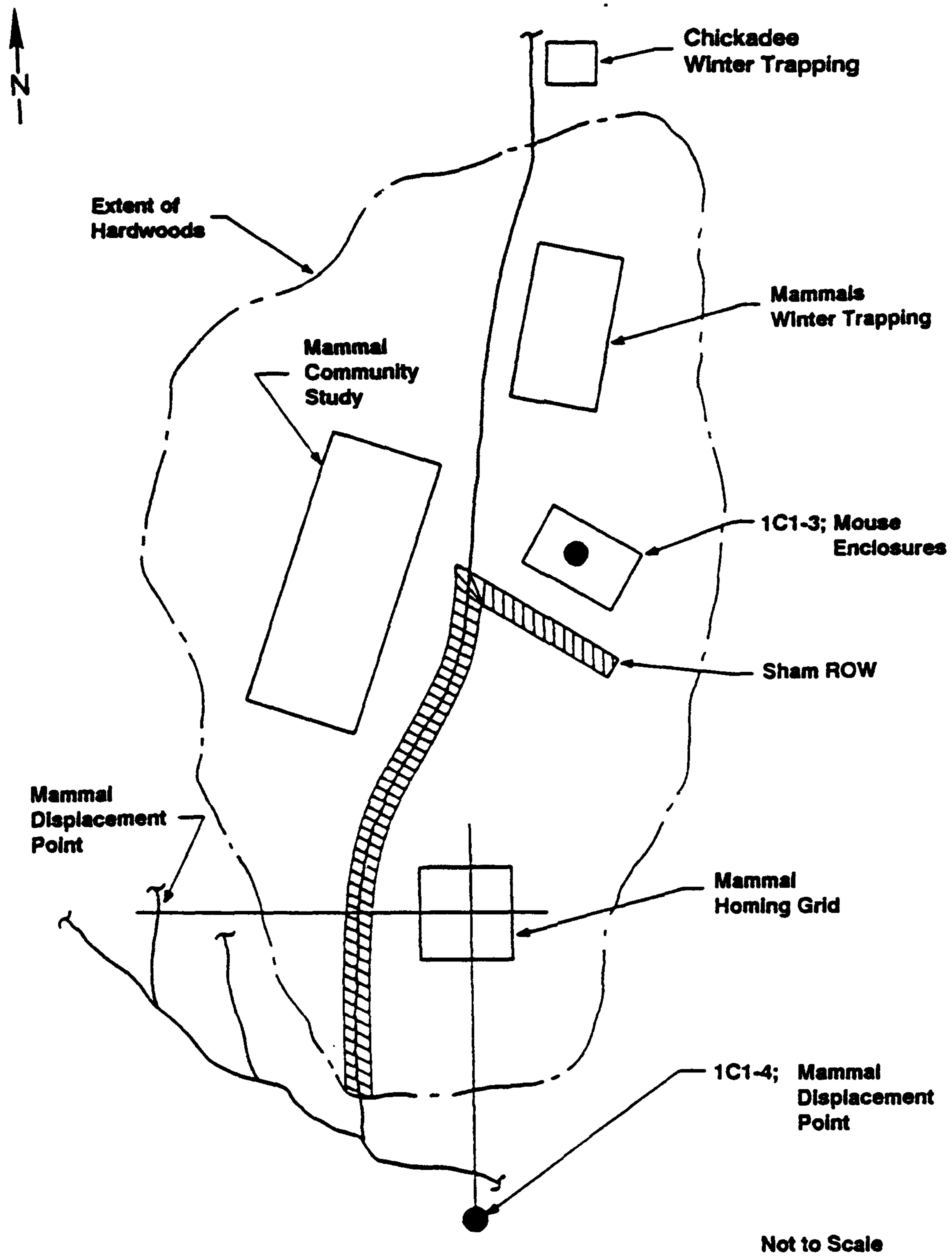



FIGURE A-2. MEASUREMENT POINTS AT MICHIGAMME NORTH; 1C1-3,4.

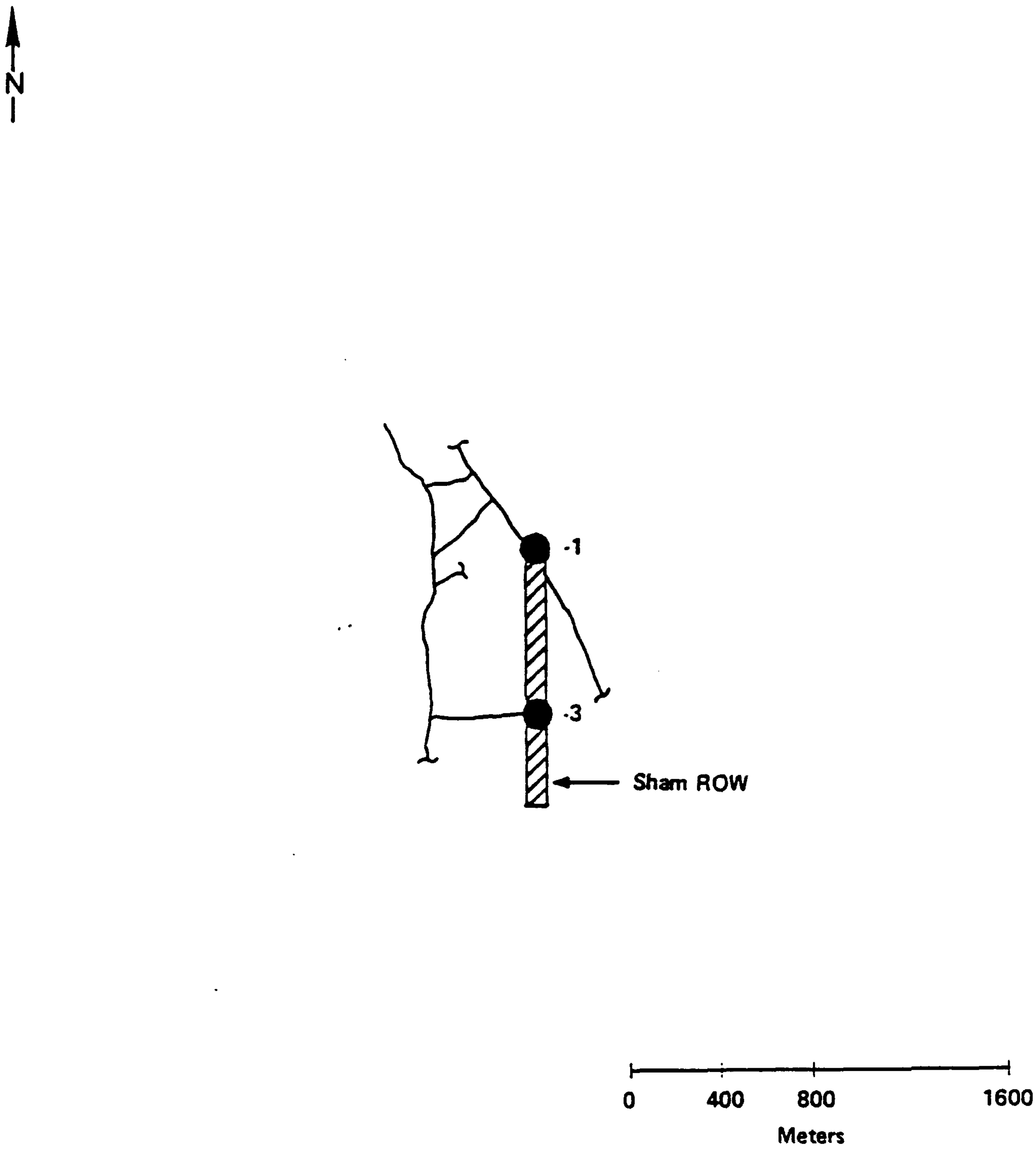



**FIGURE A-3. MEASUREMENT POINTS AT MICHIGAMME SOUTH; 1C3-1,3.**

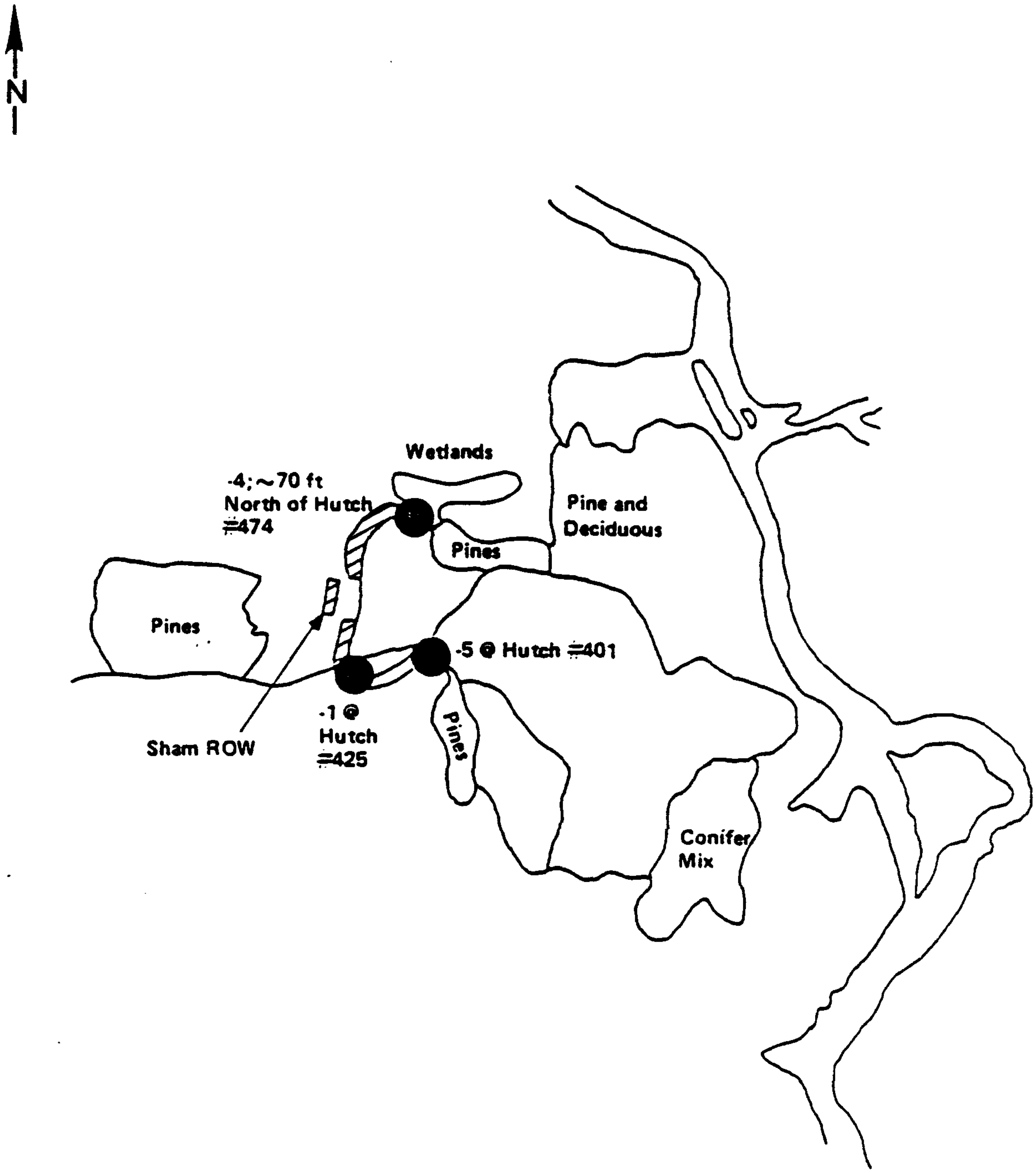



**FIGURE A-4. MEASUREMENT POINTS AT PANOLA PLAINS; 1C4-1,4,5.**

60297/790

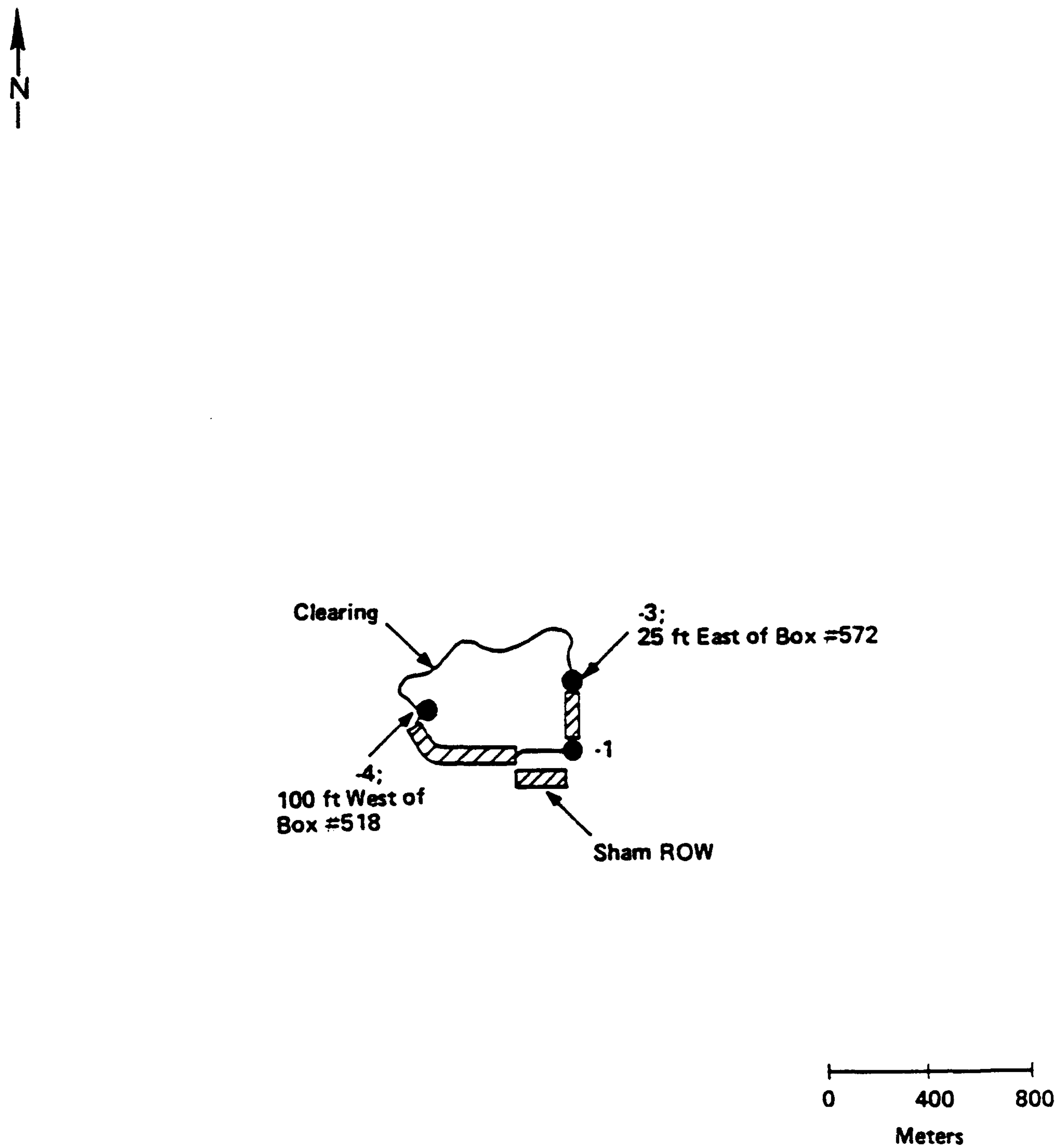



**FIGURE A-5. MEASUREMENT POINTS AT TACHYCINETA MEADOW; 1C6-1,3,4.**

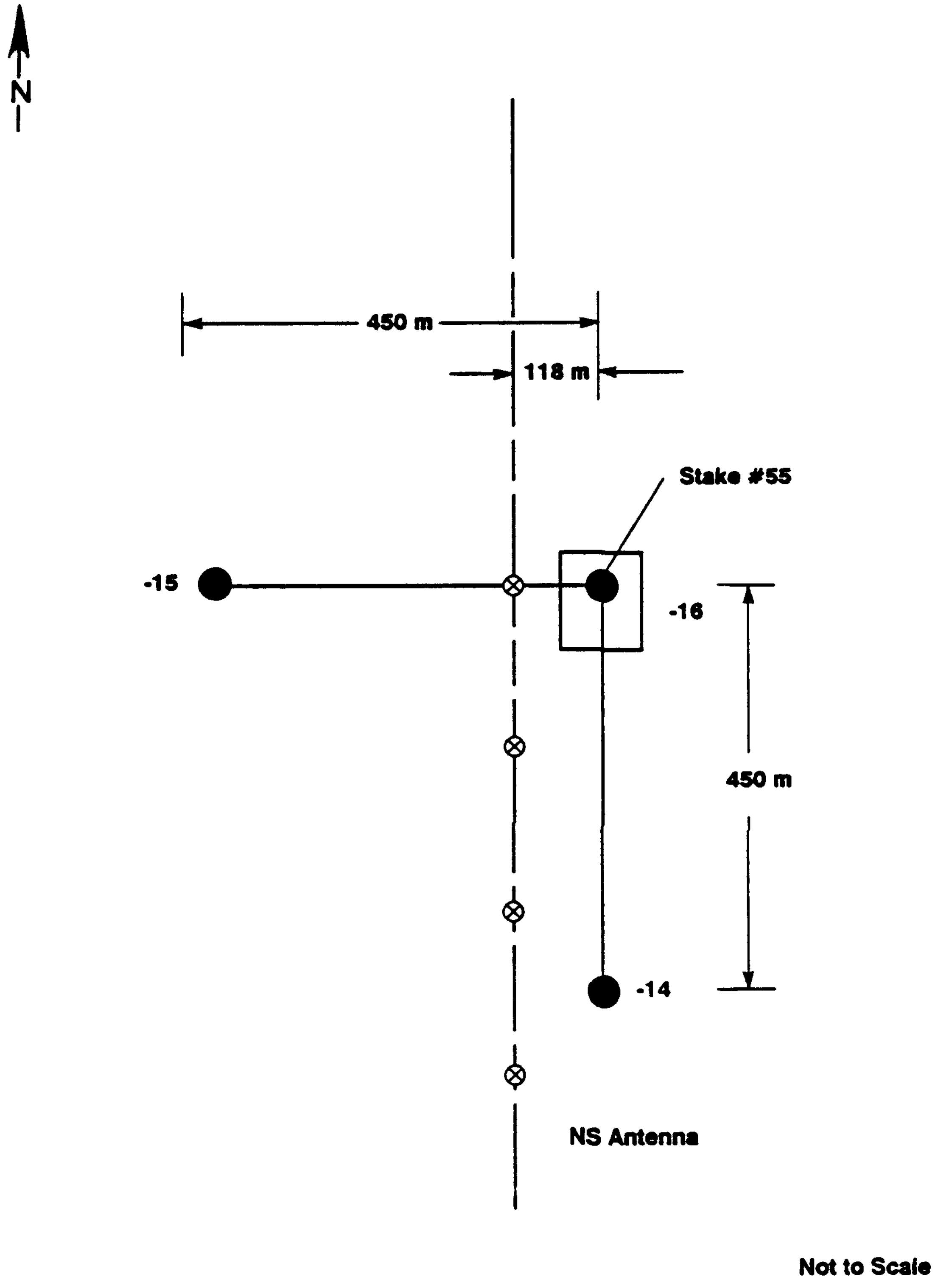



FIGURE A-6. MEASUREMENT POINTS AT PIRLOT ROAD MAMMAL DISPLACEMENT; 1T1-14, 15, 16.

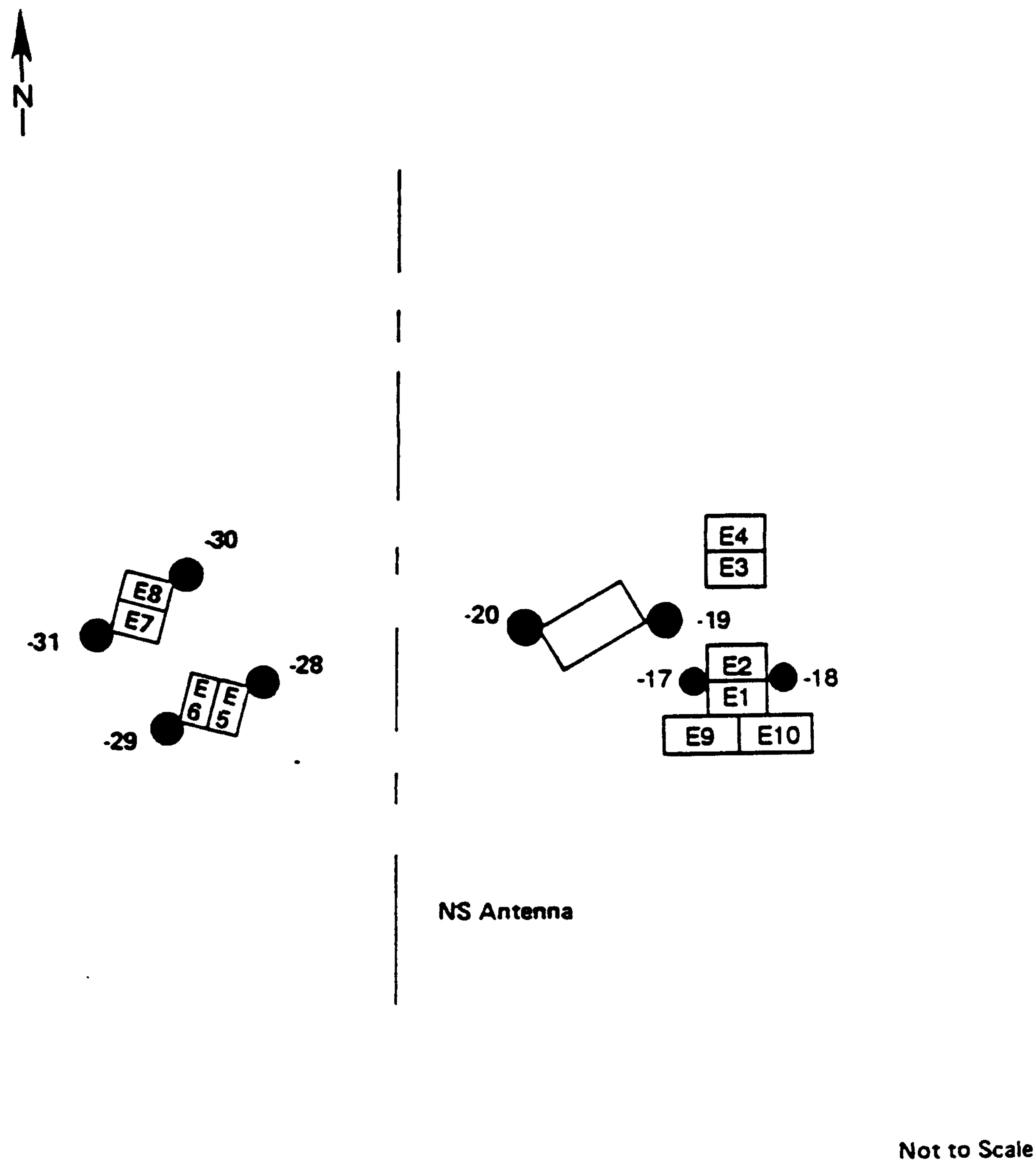



**FIGURE A-7. MEASUREMENT POINTS AT PIRLOT ROAD MOUSE ENCLOSURES; 1T1-17 THROUGH 20, 28 THROUGH 31.**

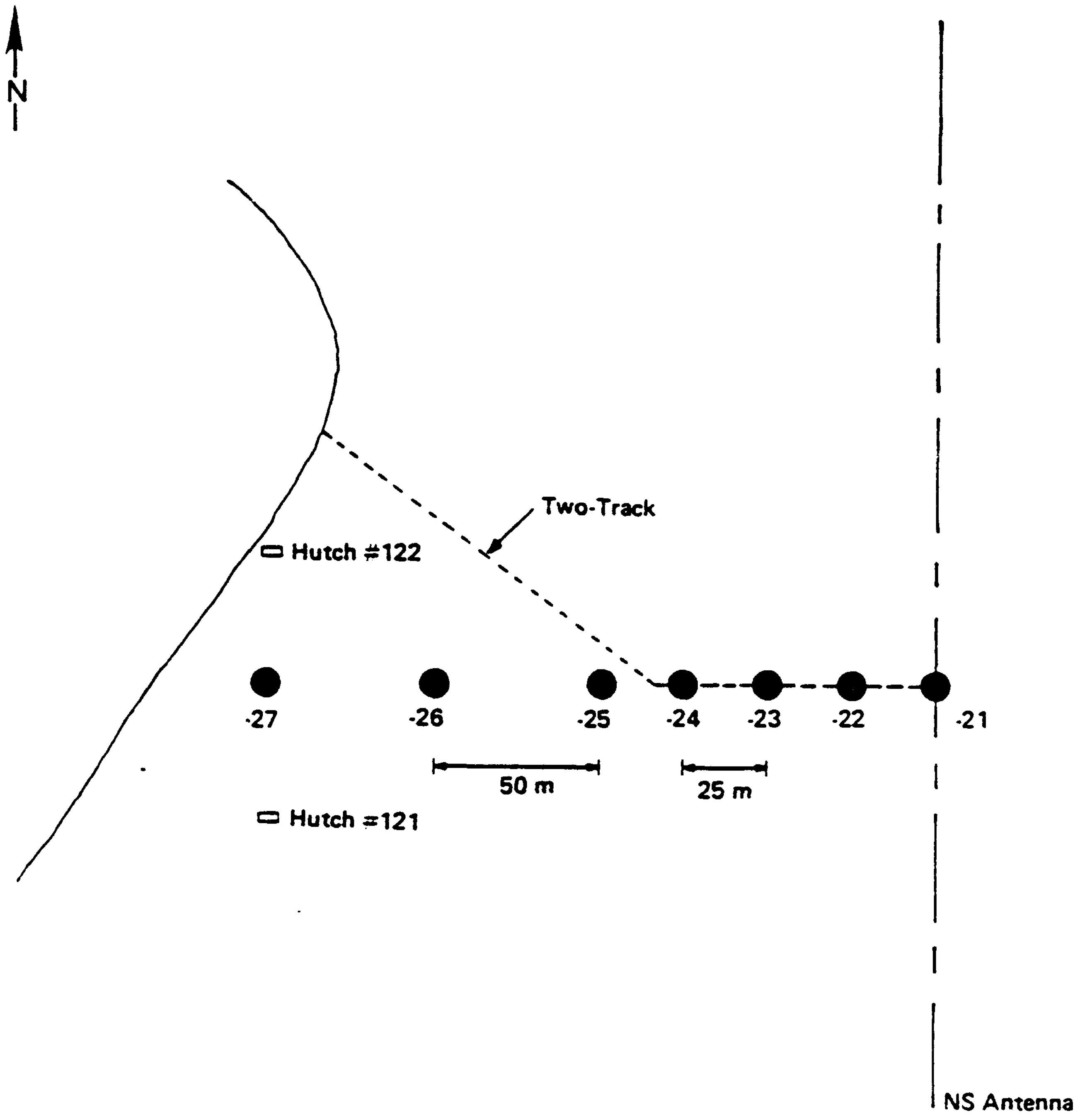



FIGURE A-8. MEASUREMENT POINTS AT PIRLOT ROAD; 1T1-21 THROUGH 27.

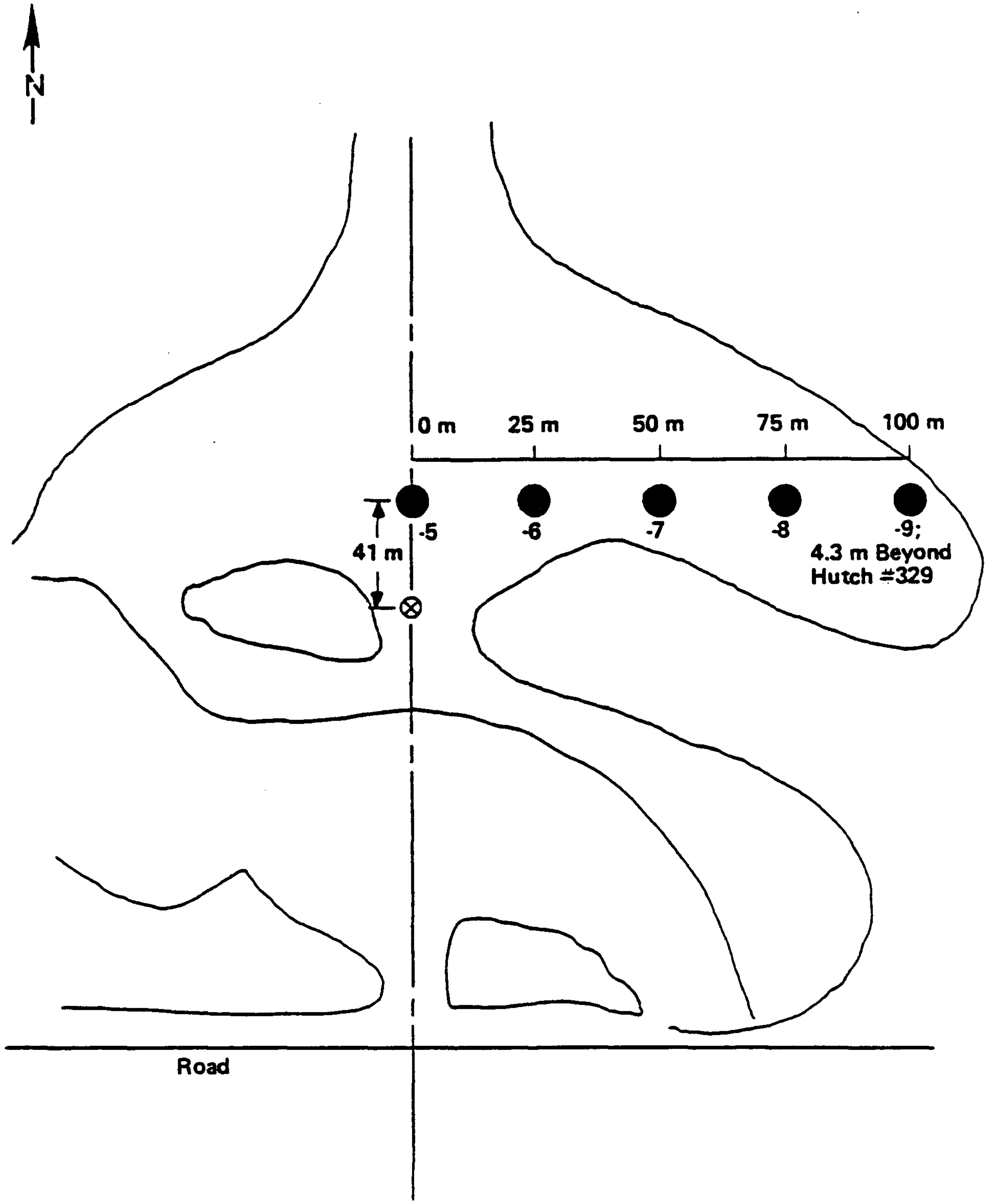



FIGURE A-9. MEASUREMENT POINTS AT CLEVELAND HOMESTEAD; 1T2-5 THROUGH 9.

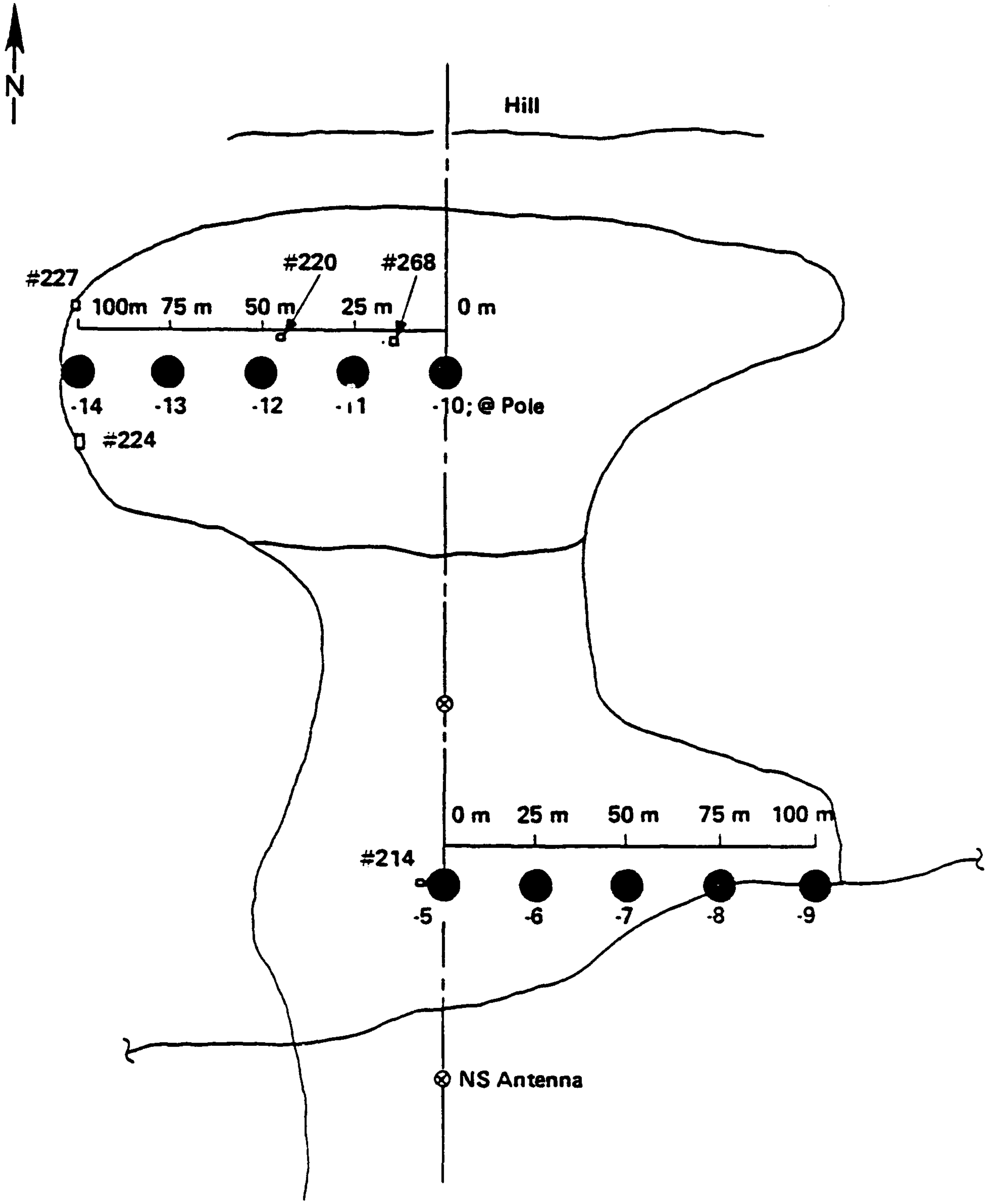



FIGURE A-10. MEASUREMENT POINTS AT NORTH TURNER ROAD; 1T4-5 THROUGH 14.

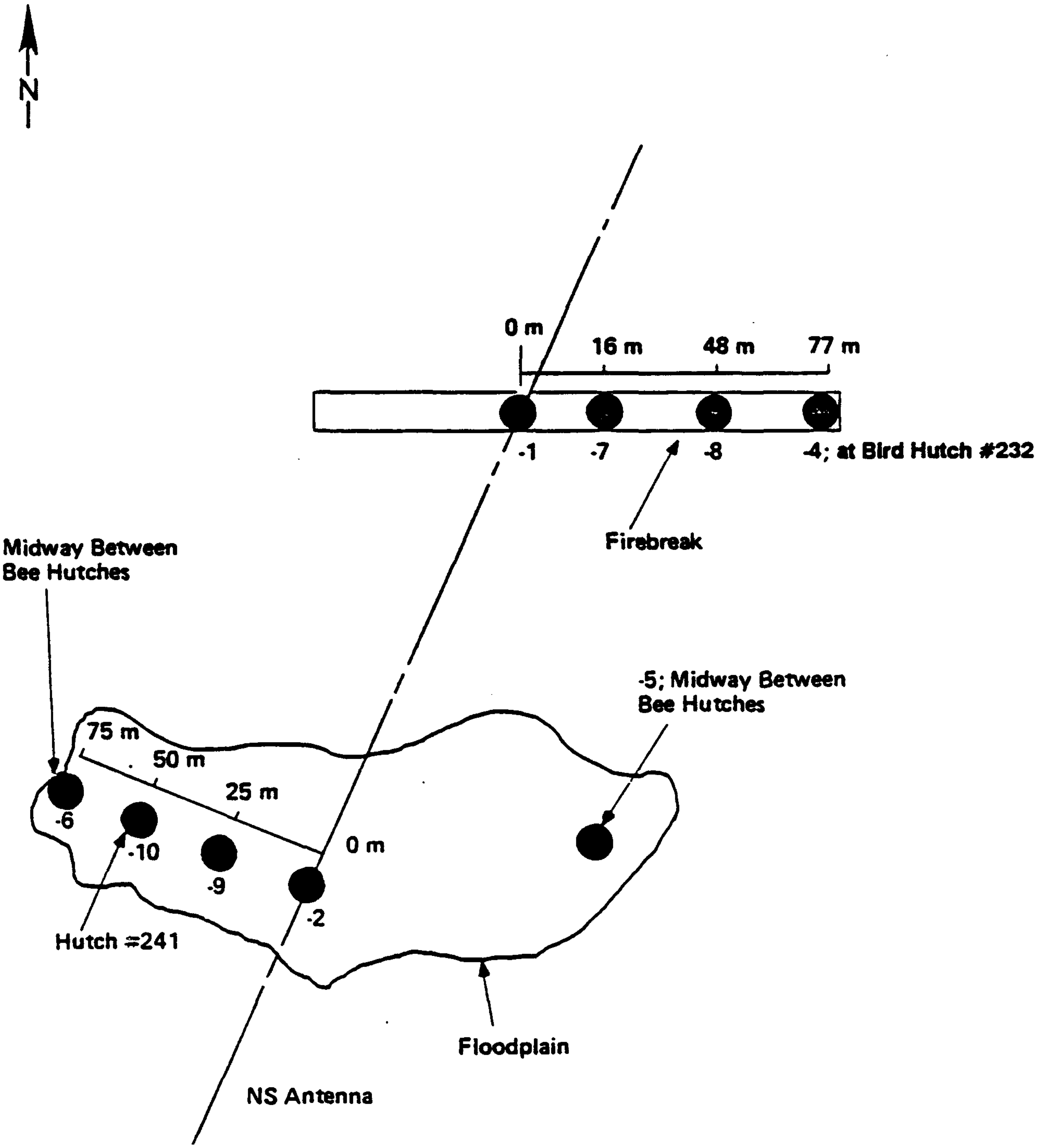



FIGURE A-11. MEASUREMENT POINTS AT FORD RIVER NORTH; 1T5-1, 2, 4, 6, 7, 8, 9, 10.

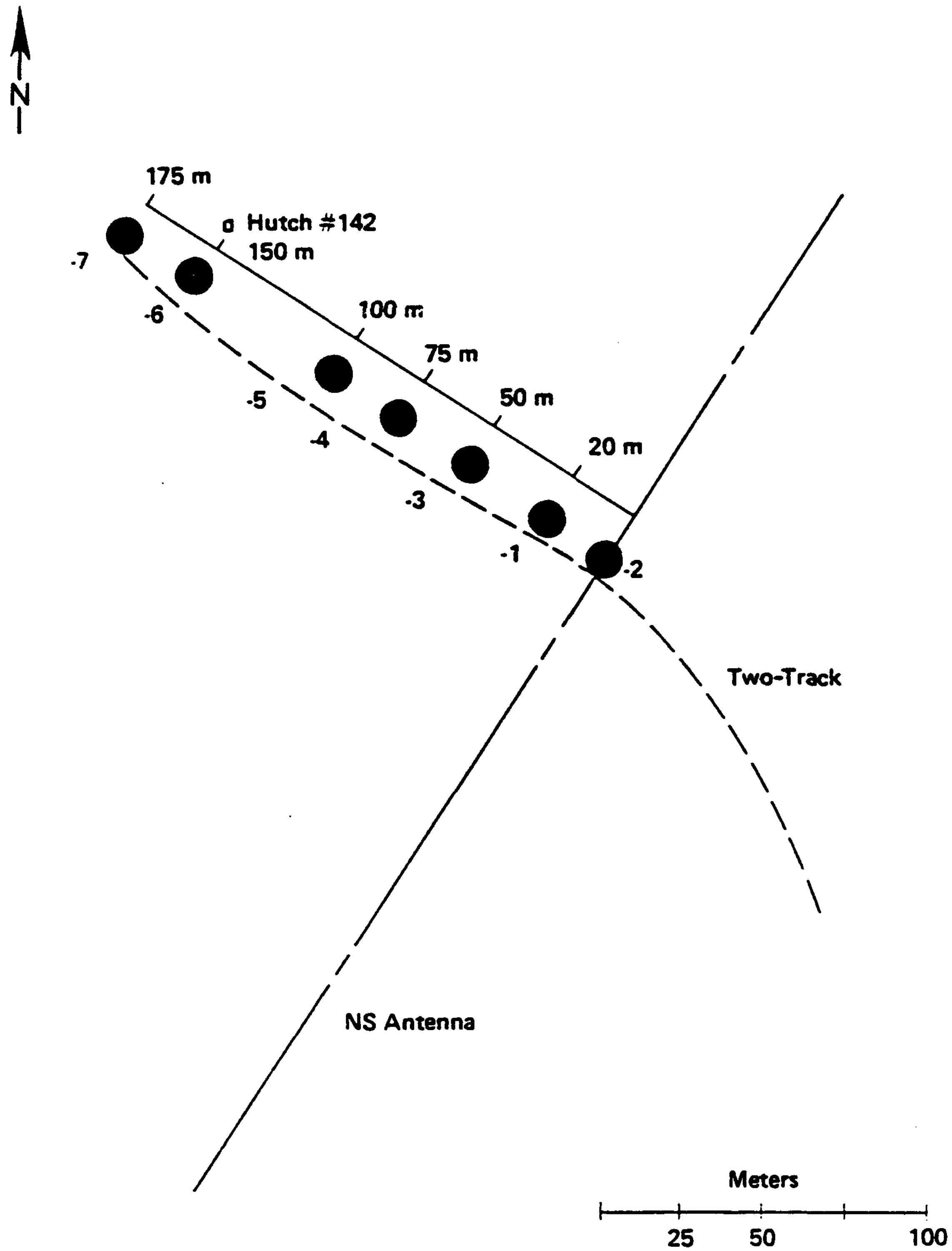



FIGURE A-12. MEASUREMENT POINTS AT FORD RIVER SOUTH; 1T6-1 THROUGH 7.

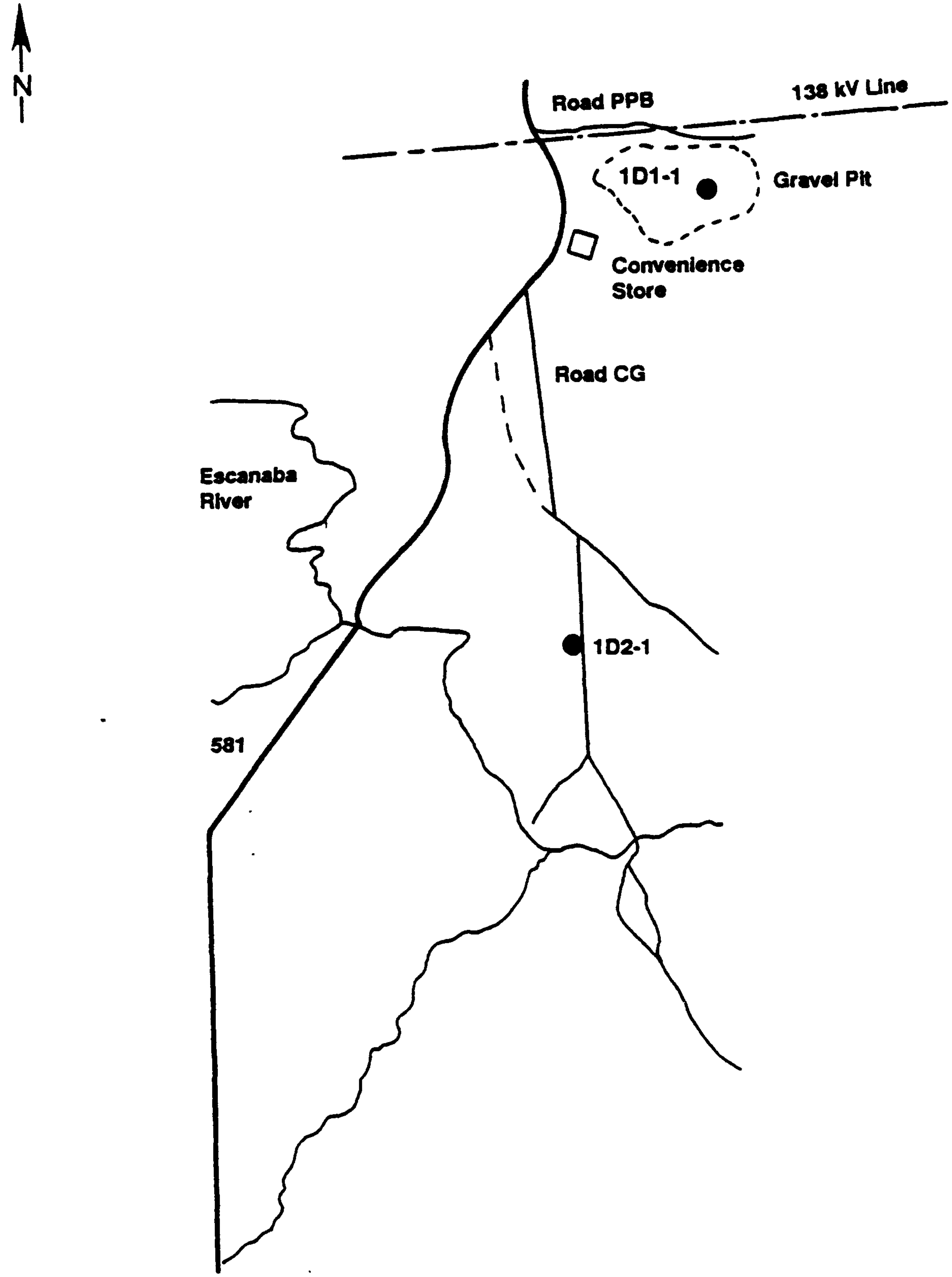



FIGURE A-13. MEASUREMENT POINTS AT CLEVELAND HOMESTEAD AND NORTH TURNER ROAD DISPLACEMENT POINTS; 1D1-1 AND 1D2-1.

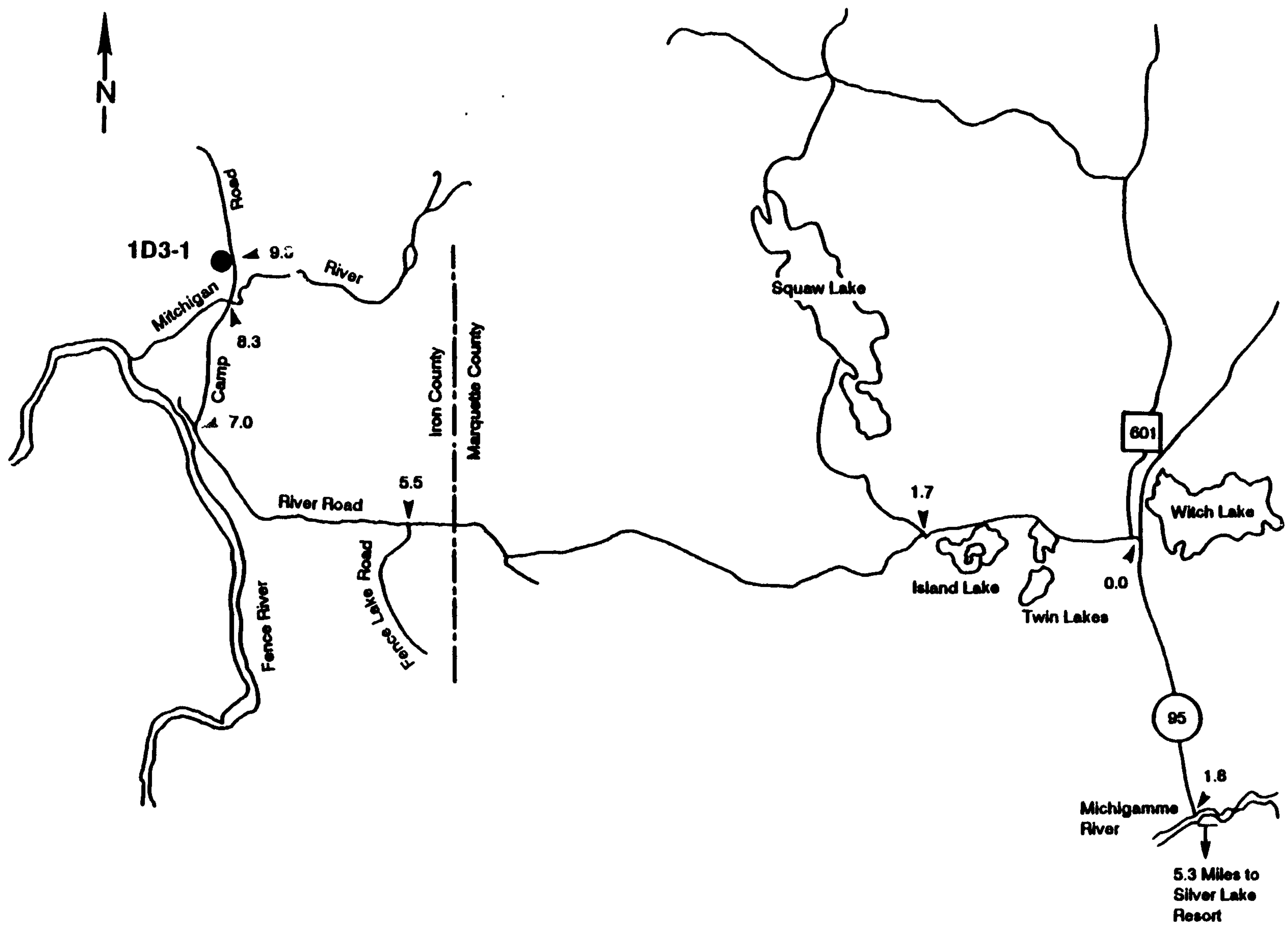



FIGURE A-14. MEASUREMENT POINT AT PANOLA PLAINS DISPLACEMENT; 1D3-1.

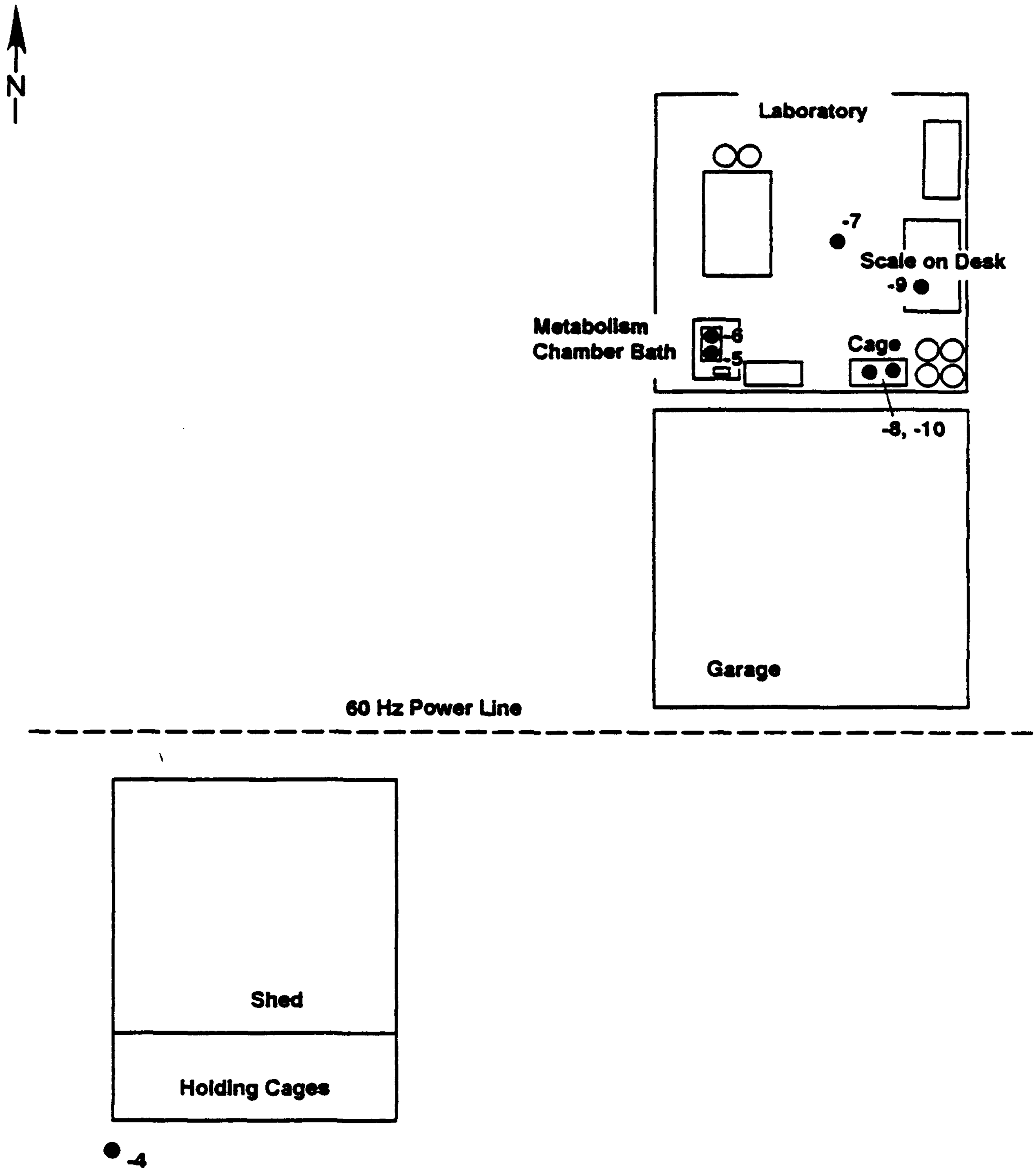



FIGURE A-15. MEASUREMENT POINTS AT MAMMAL LABORATORY; 1L1-4 THROUGH 1L1-10.

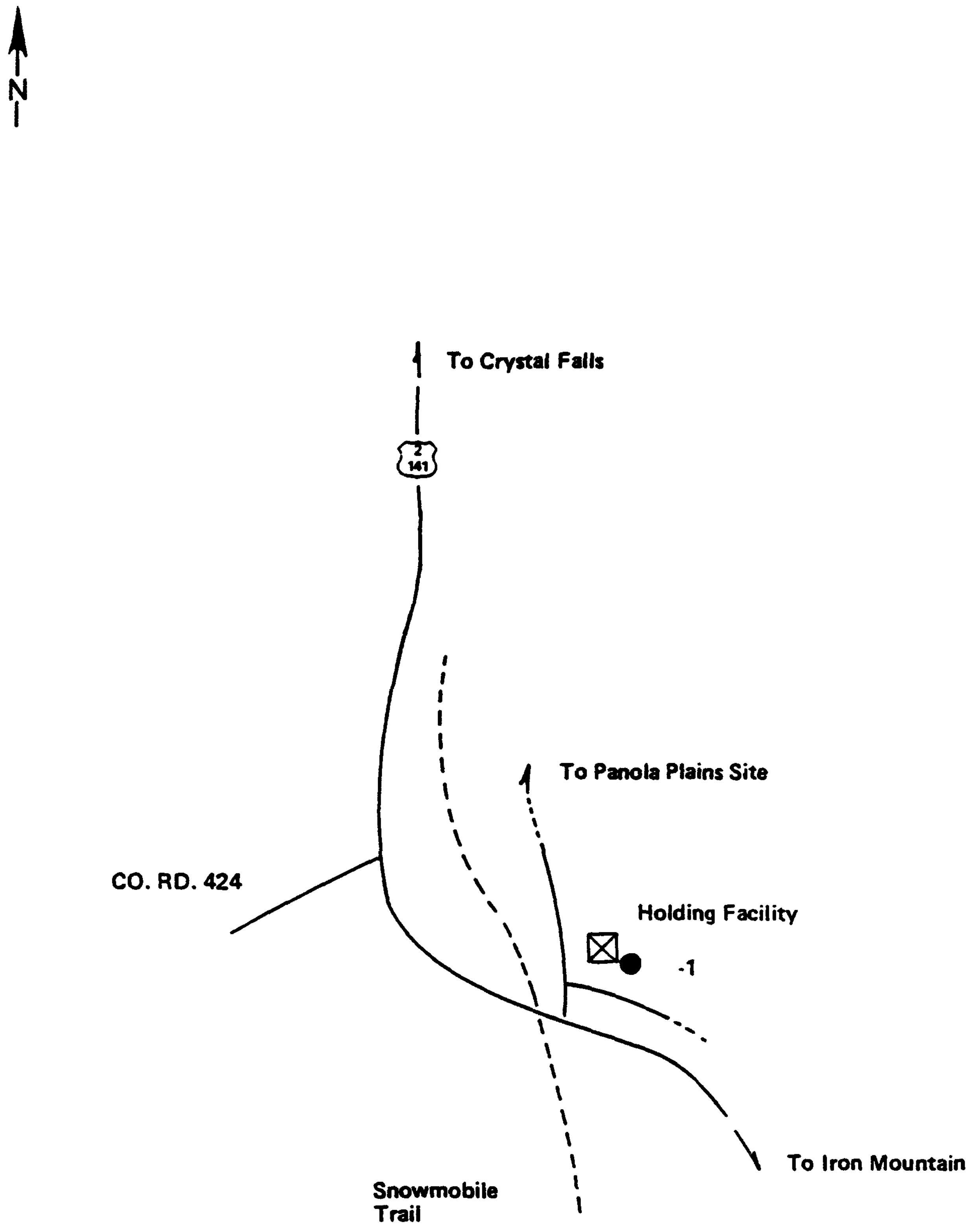



FIGURE A-16. MEASUREMENT POINT AT REMOTE HOLDING FACILITY; 1L4-1.

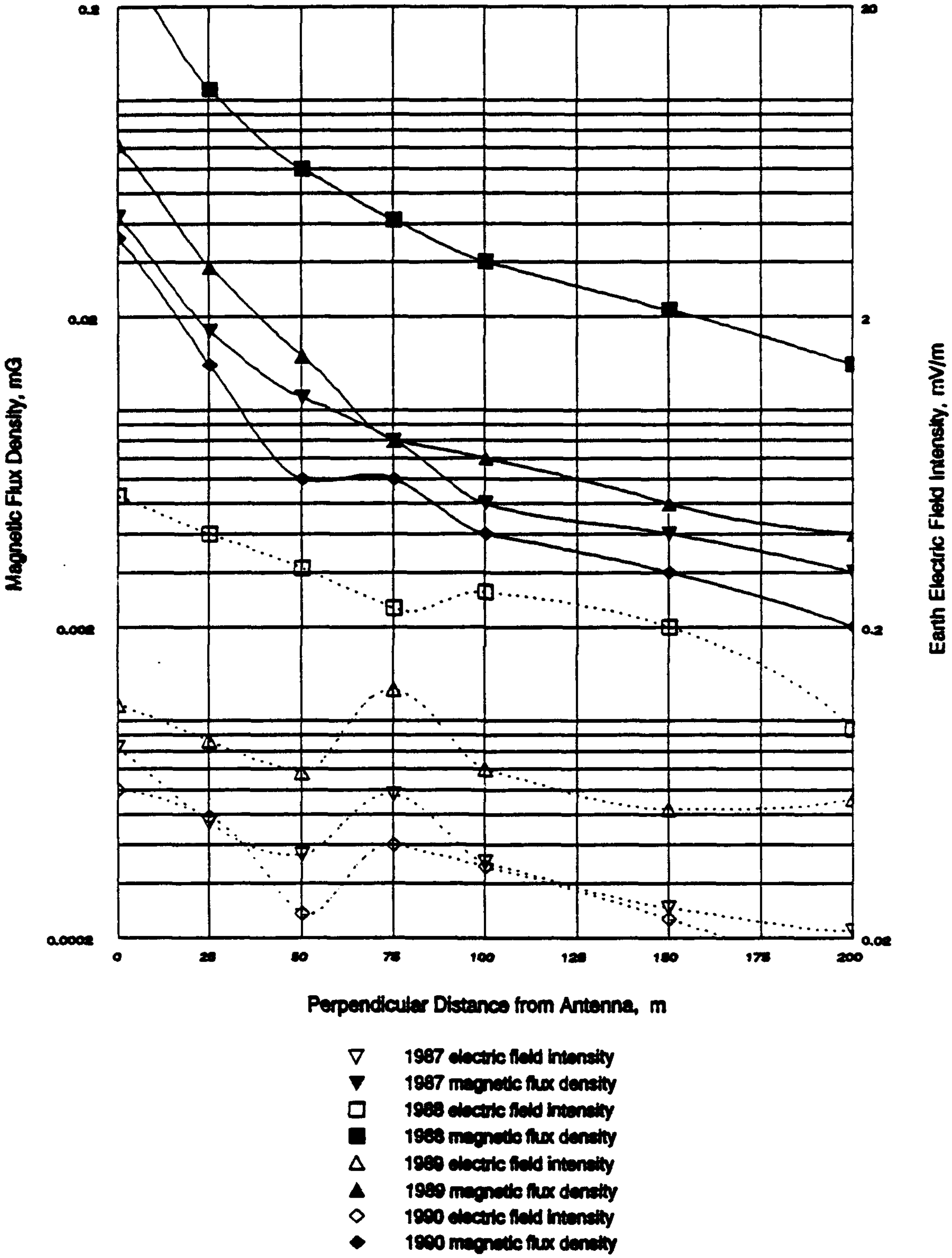



FIGURE A-17. 60 Hz MAGNETIC AND EARTH ELECTRIC FIELD PROFILES, PIRLOT ROAD; 1T1-21 THROUGH 27.

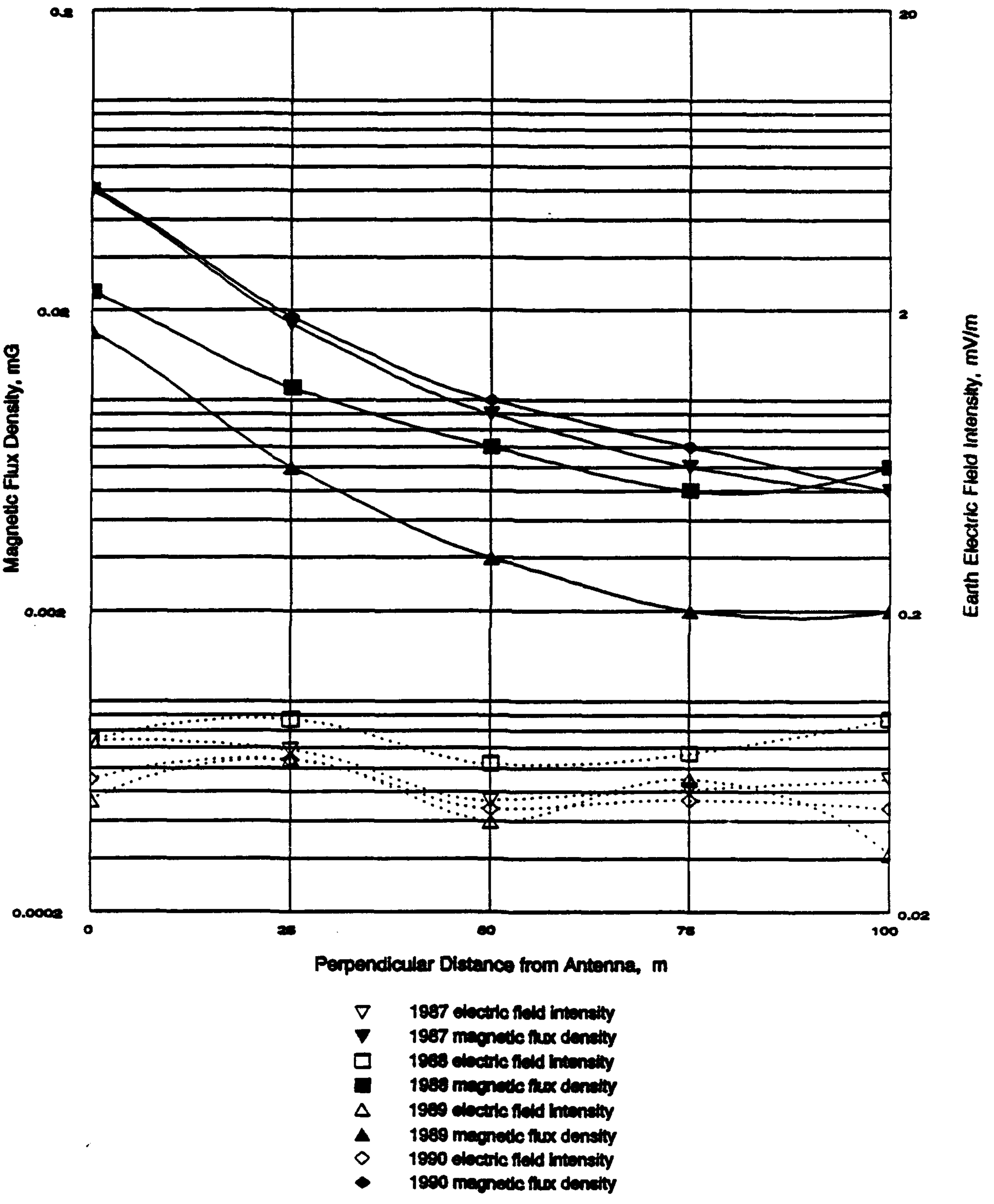



FIGURE A-18. 60 Hz MAGNETIC AND EARTH ELECTRIC FIELD PROFILES, CLEVELAND HOMESTEAD; 1T2-5 THROUGH 9.

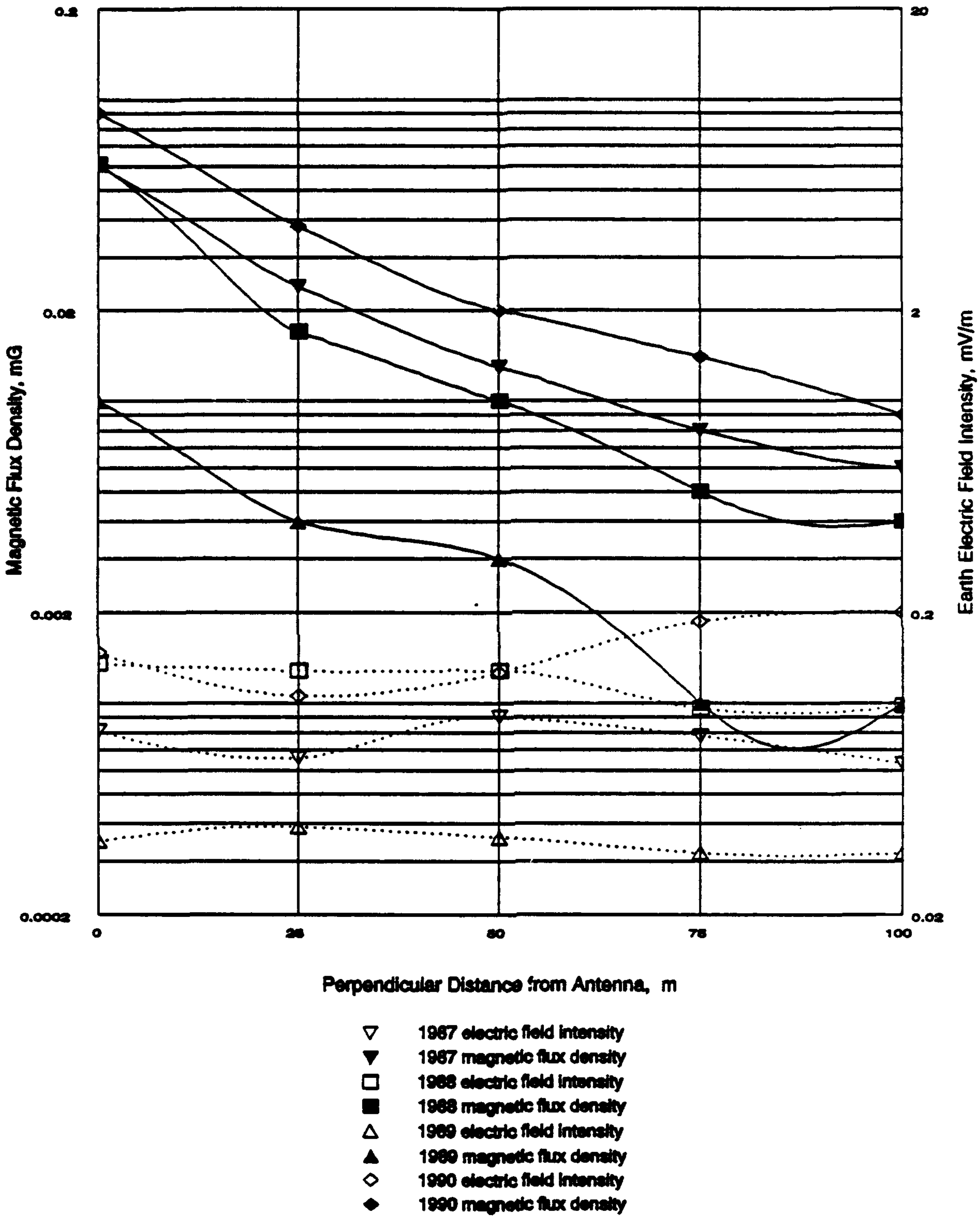



**FIGURE A-19. 60 Hz MAGNETIC AND EARTH ELECTRIC FIELD PROFILES, NORTH TURNER ROAD; 1T4-5 THROUGH 9.**

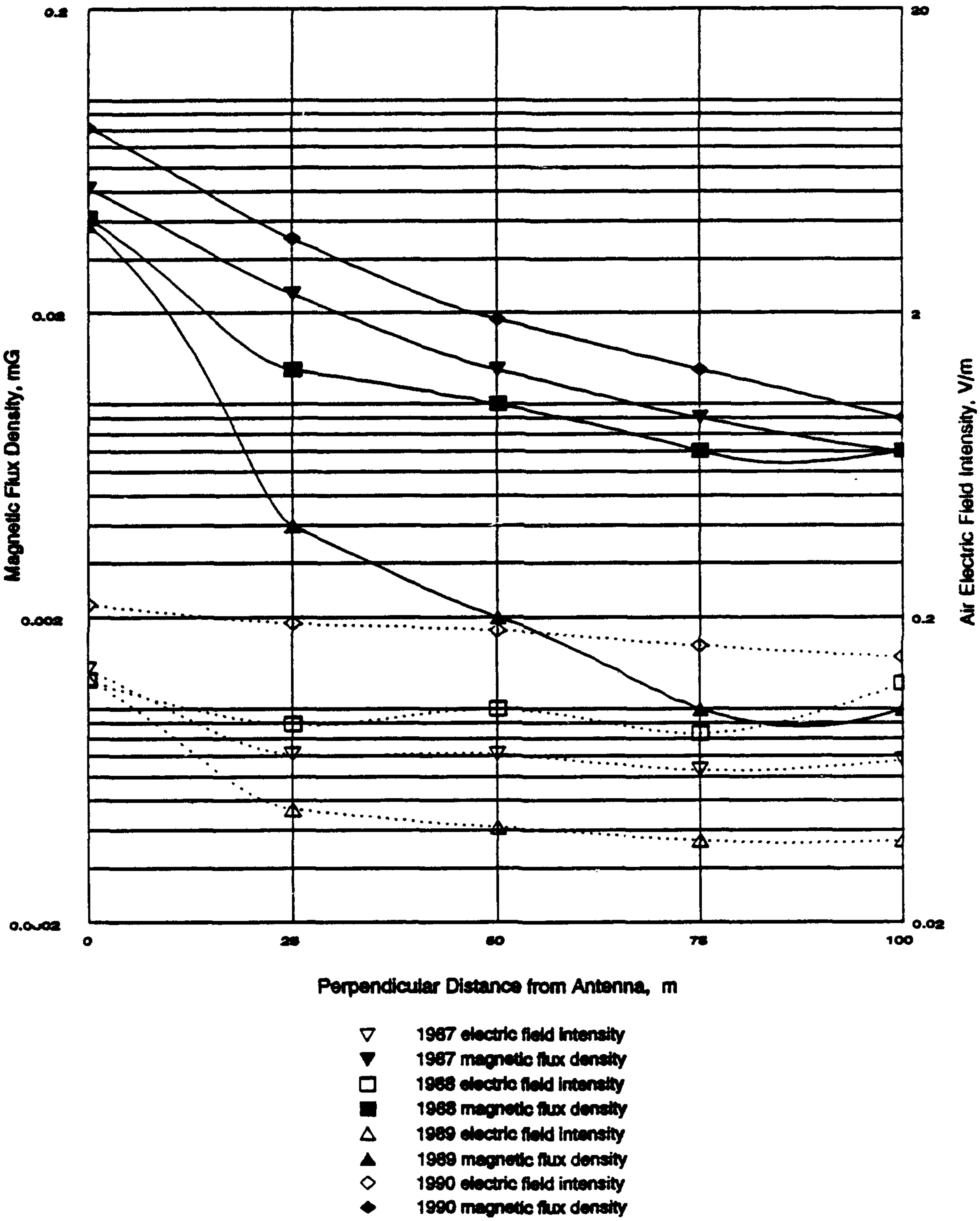



**FIGURE A-20. 60 Hz MAGNETIC AND EARTH ELECTRIC FIELD PROFILES, NORTH TURNER ROAD; 1T4-10 THROUGH 14.**

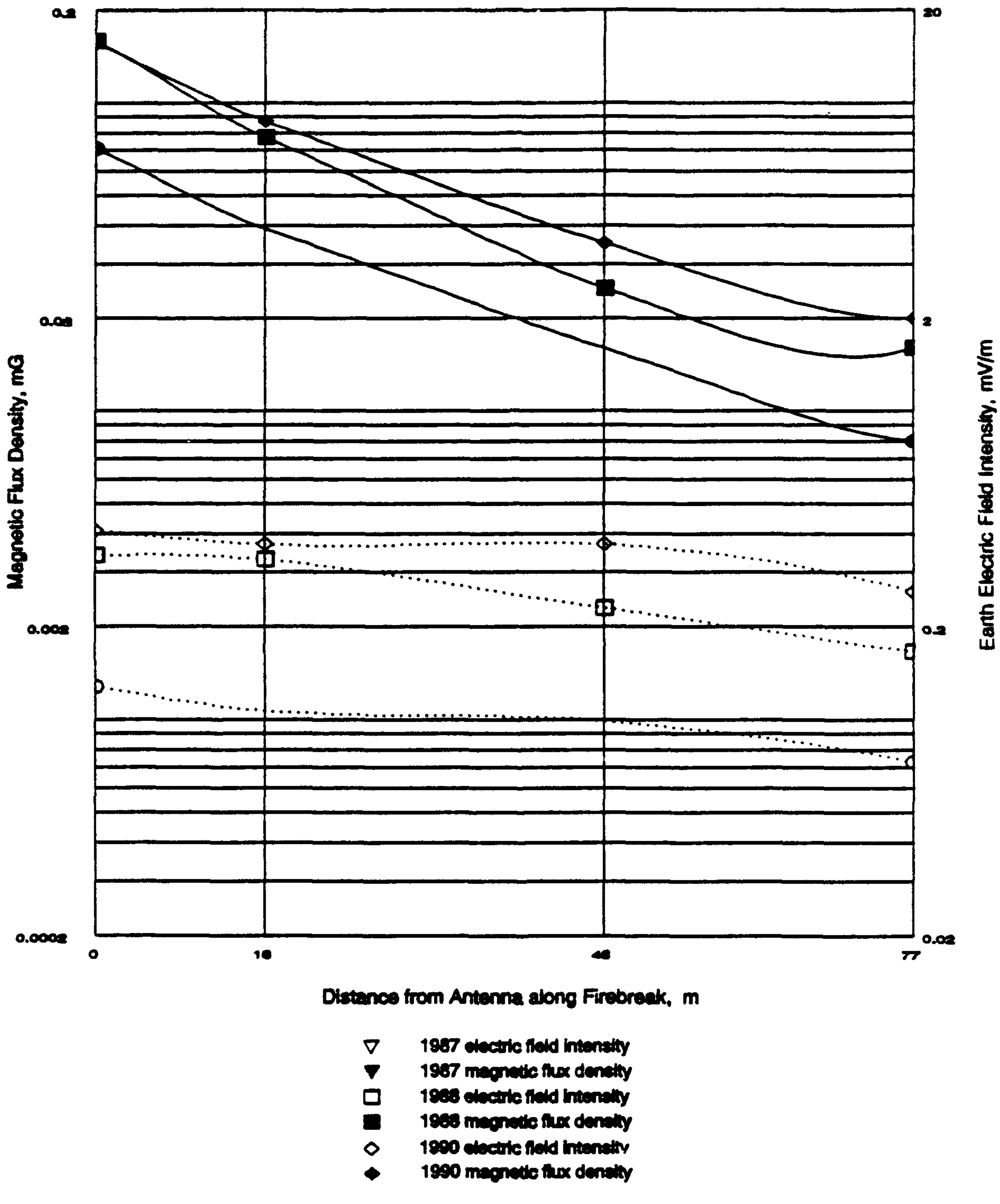



**FIGURE A-21. 60 Hz MAGNETIC AND EARTH ELECTRIC FIELD PROFILES, FORD RIVER NORTH; 1T5-1, 7, 8, 4.**

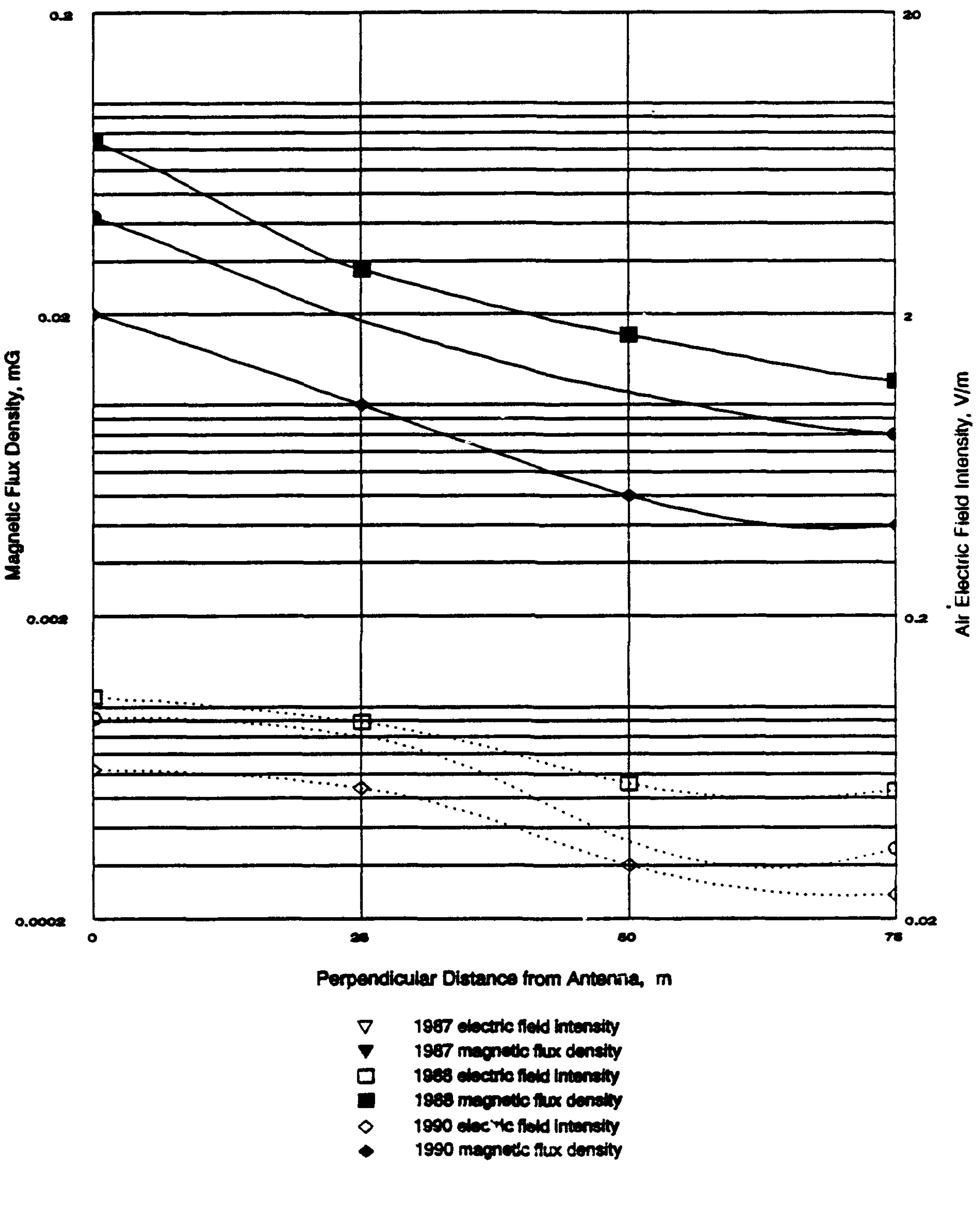



**FIGURE A-22. 60 Hz MAGNETIC AND EARTH ELECTRIC FIELD PROFILES, FORD RIVER NORTH; 1T5-2, 9, 10, 6.**

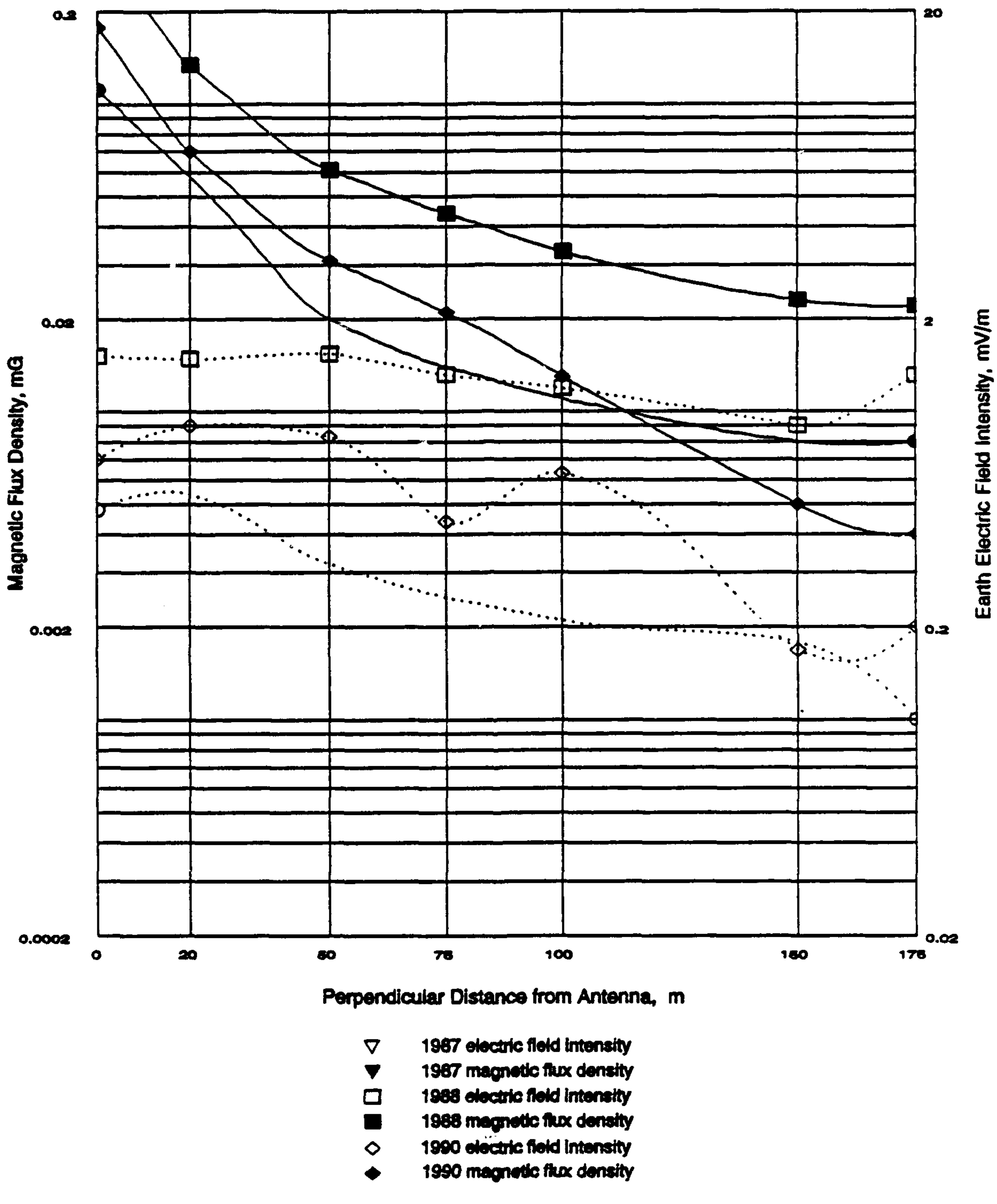



FIGURE A-23. 60 Hz MAGNETIC AND EARTH ELECTRIC FIELD PROFILES, FORD RIVER SOUTH; 1T6-2, 1, 3, 4, 5, 6, 7.

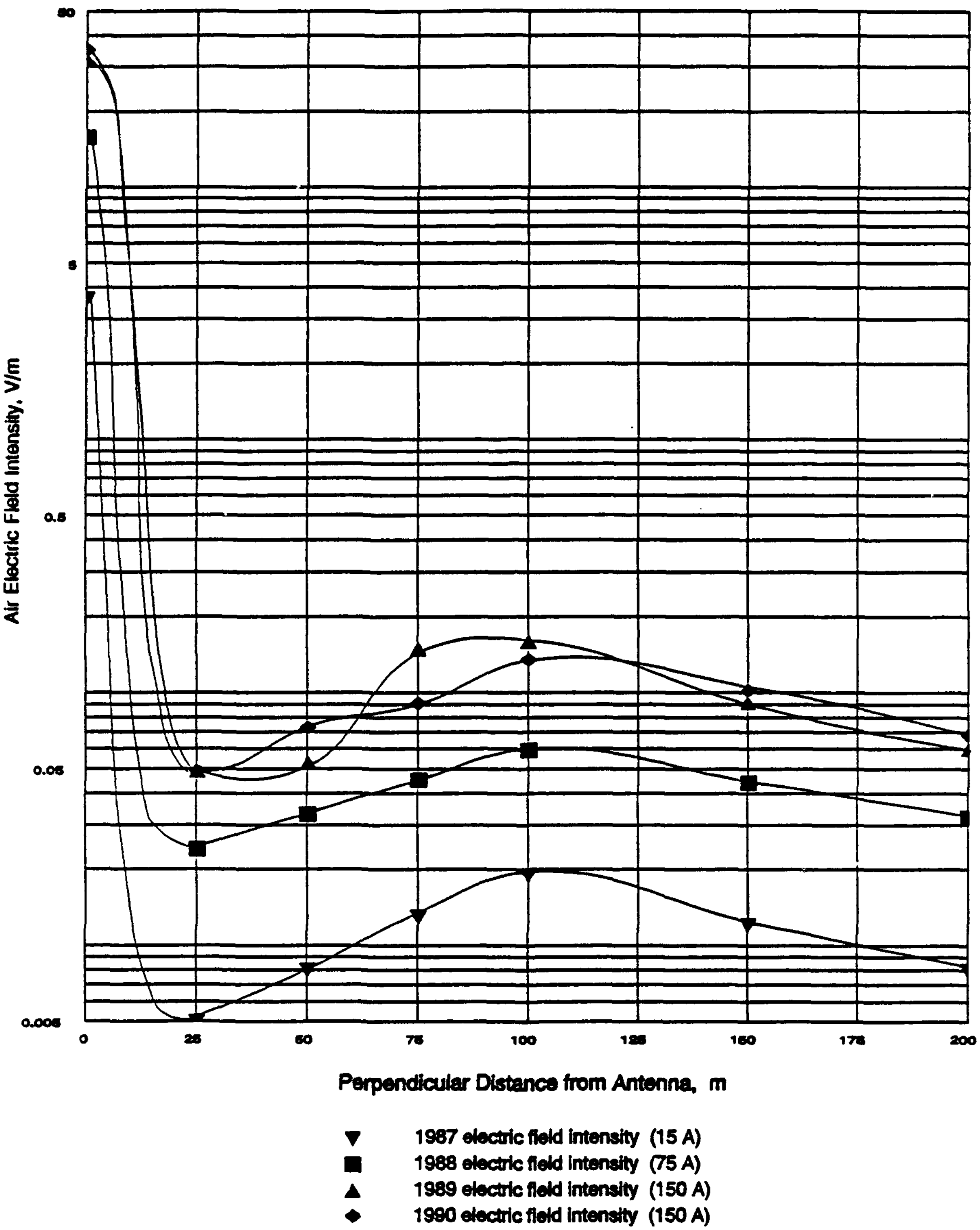



**FIGURE A-24. 76 Hz AIR ELECTRIC FIELD PROFILES, PIRLOT ROAD; 1T1-21 THROUGH 27.**

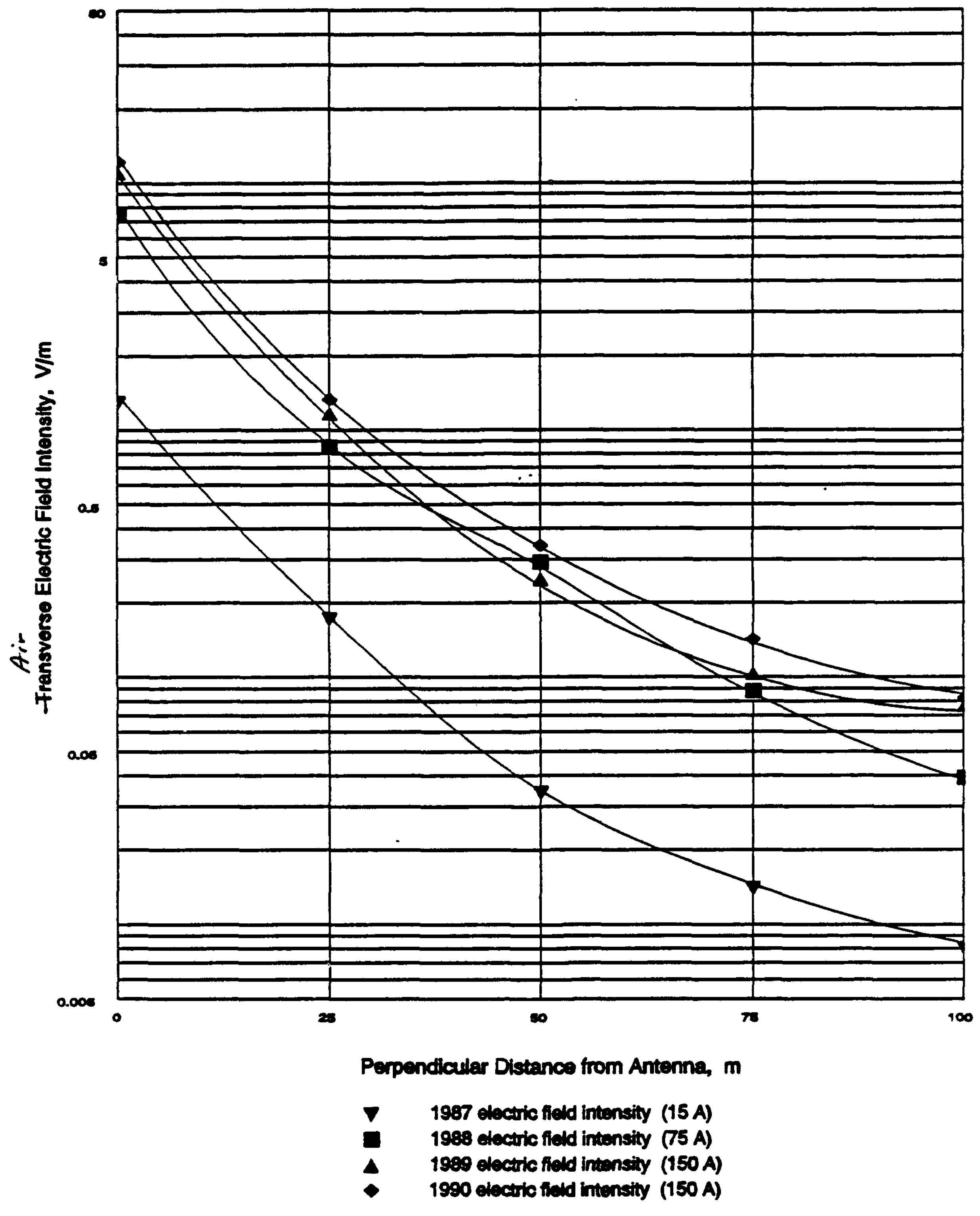



FIGURE A-25. 76 Hz AIR ELECTRIC FIELD PROFILES, CLEVELAND HOMESTEAD; 1T2-5 THROUGH 9.

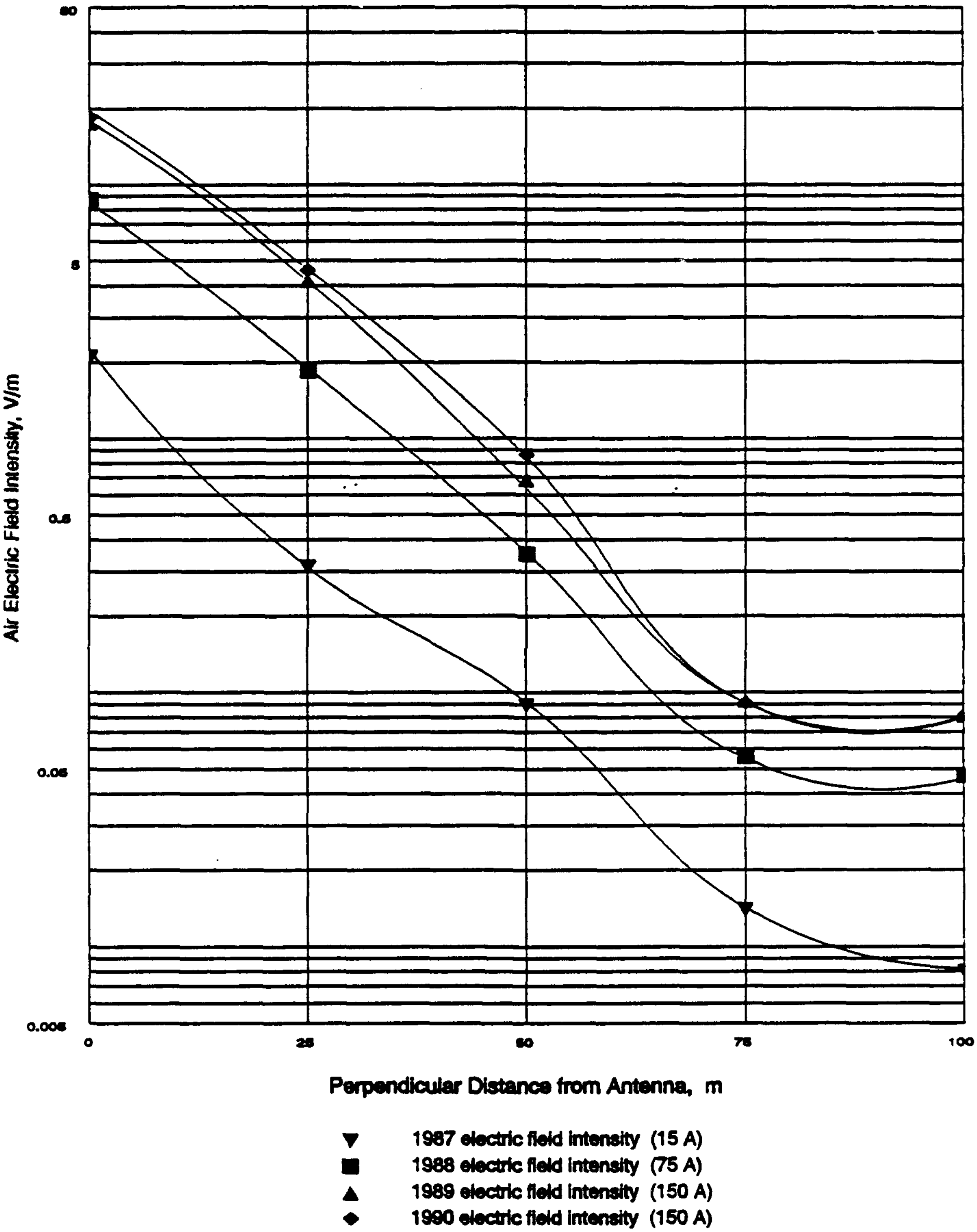



**FIGURE A-26. 76 Hz AIR ELECTRIC FIELD PROFILES, NORTH TURNER ROAD; 1T4-5 THROUGH 9.**

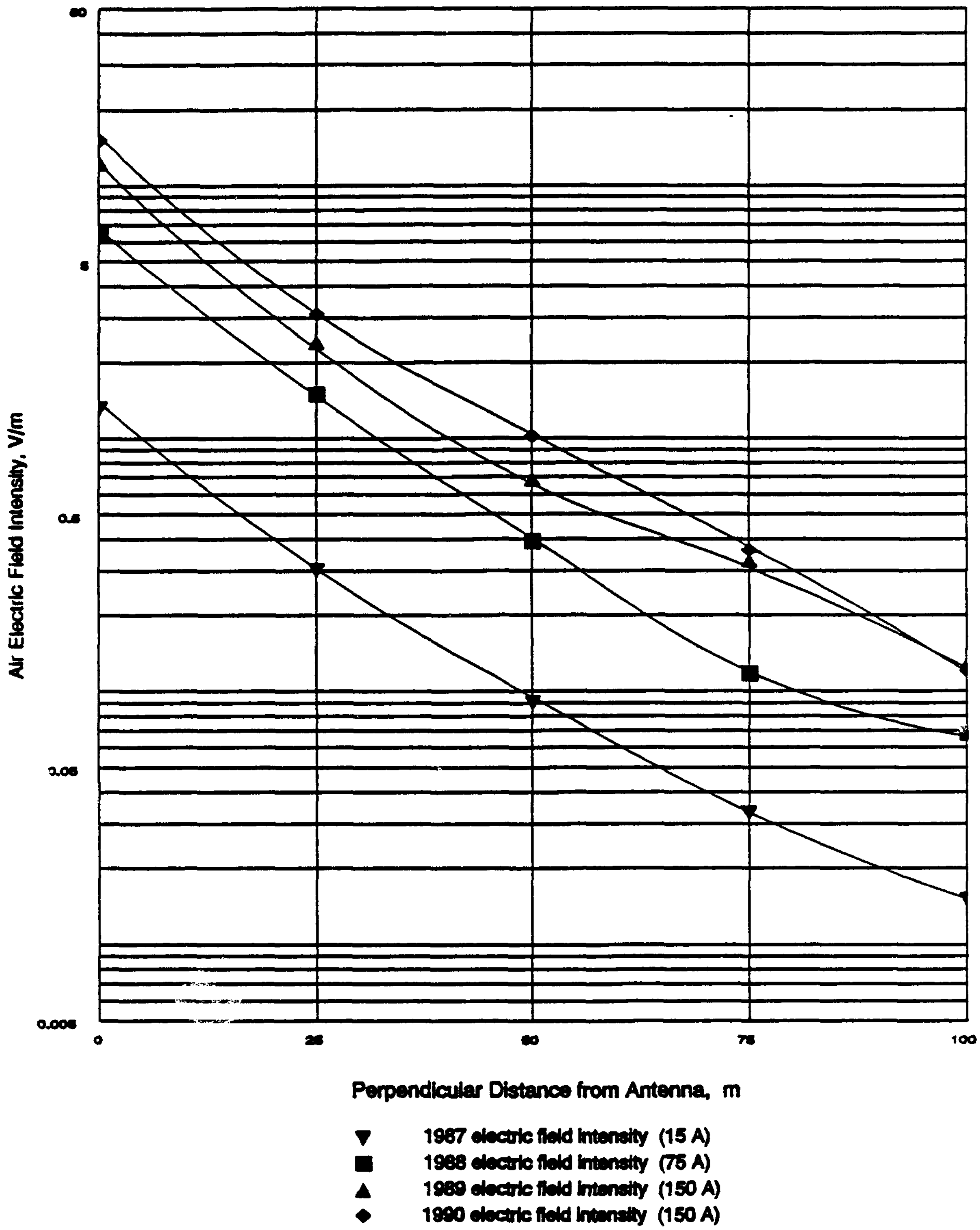



**FIGURE A-27. 76 Hz AIR ELECTRIC FIELD PROFILES, NORTH TURNER ROAD; 1T4-10 THROUGH 14.**

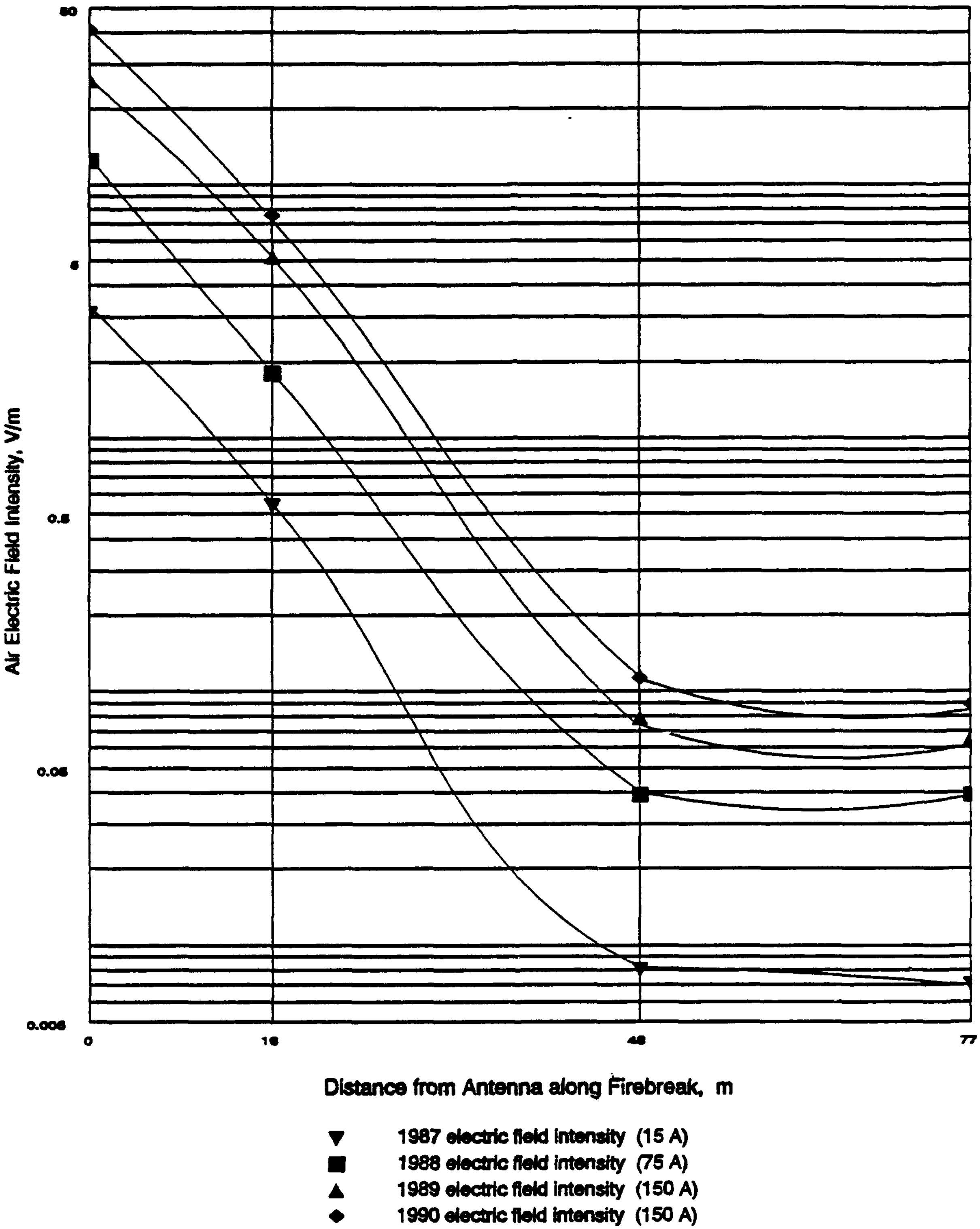



**FIGURE A-28. 76 Hz AIR ELECTRIC FIELD PROFILES, FORD RIVER NORTH; 1T5-1, 7, 8, 4.**

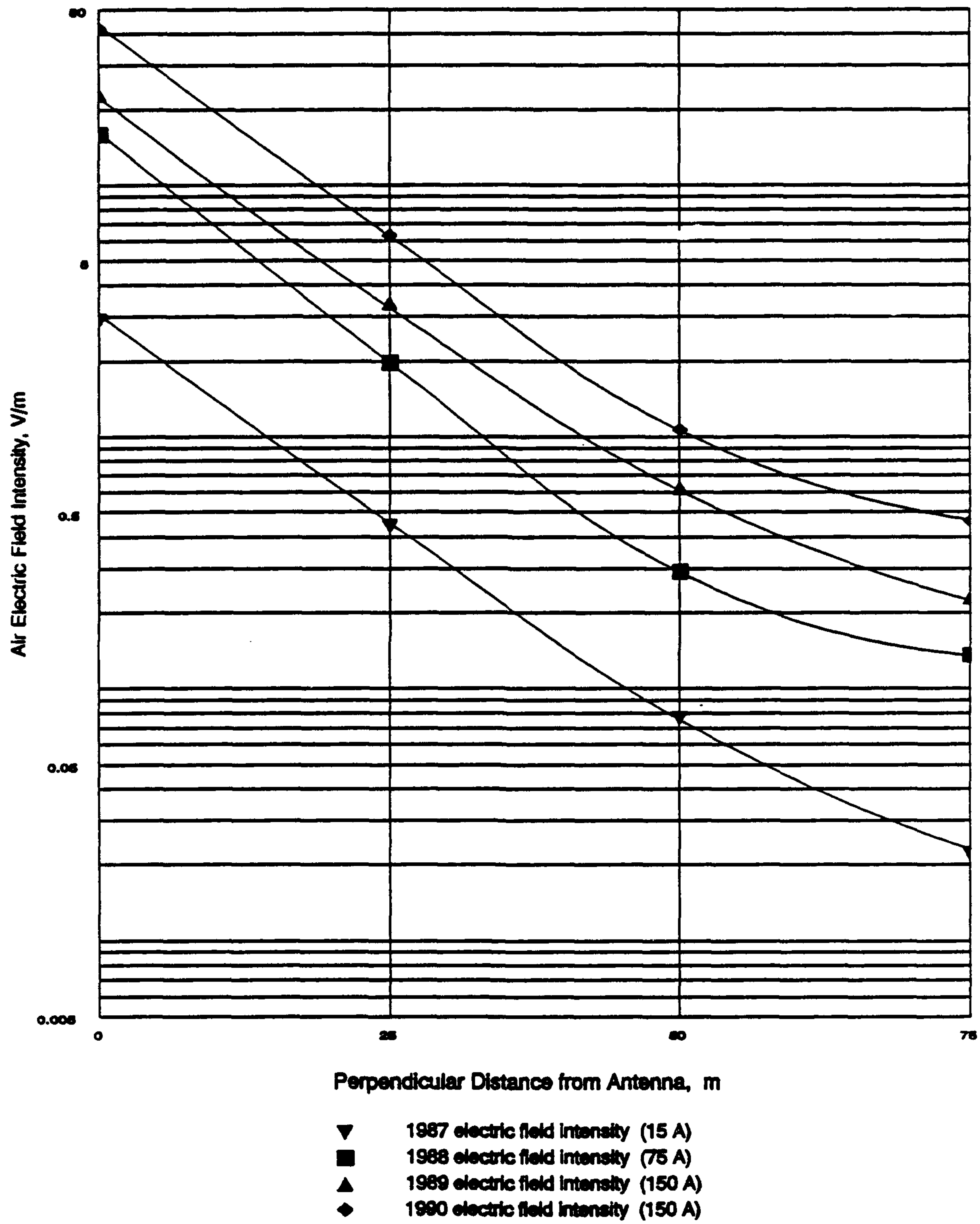



**FIGURE A-29. 76 Hz AIR ELECTRIC FIELD PROFILES, FORD RIVER NORTH; 1T5-2, 9, 10, 6.**

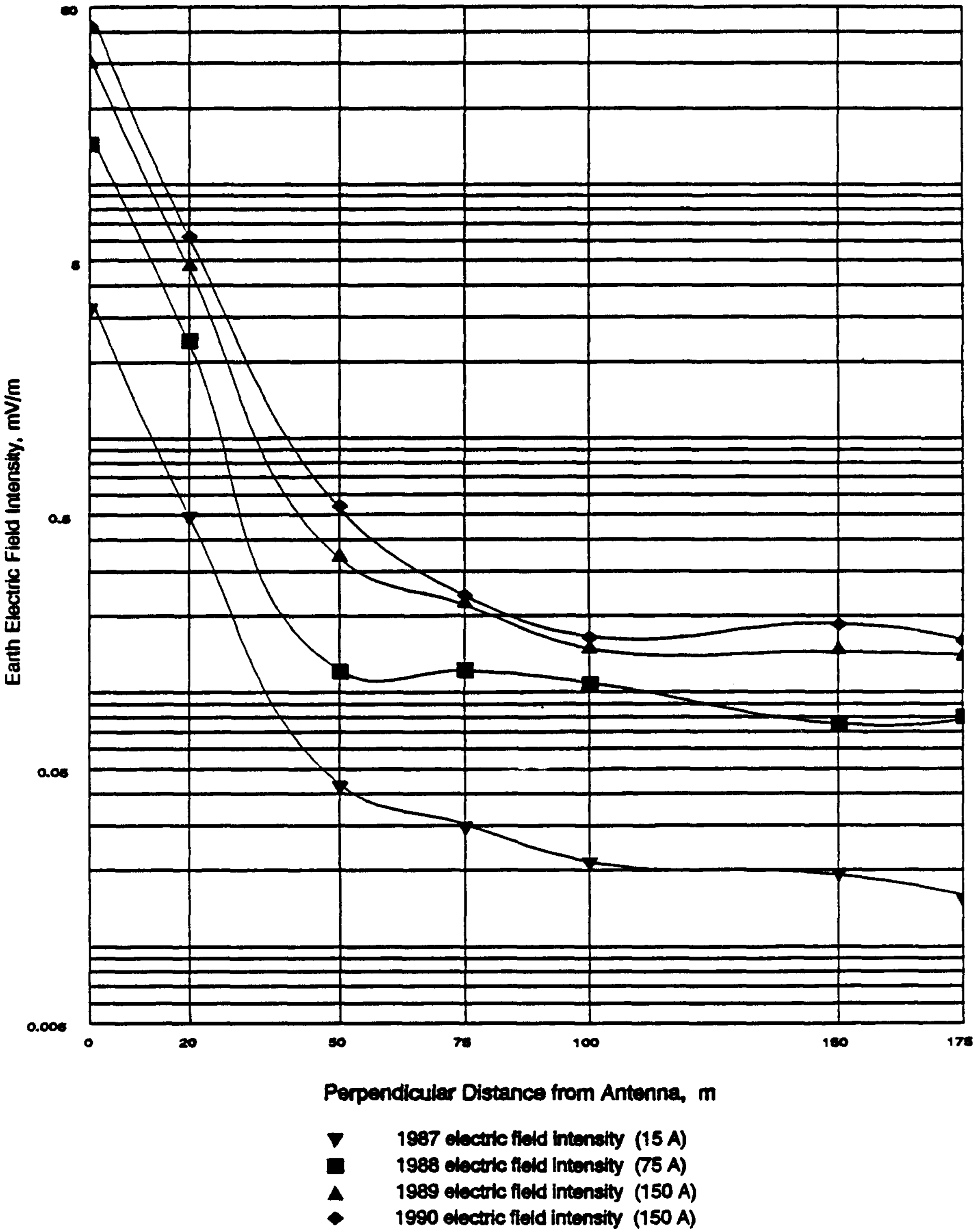



**FIGURE A-30. 76 Hz AIR ELECTRIC FIELD PROFILES, FORD RIVER SOUTH; 1T6-2, 1, 3, 4, 5, 6, 7.**

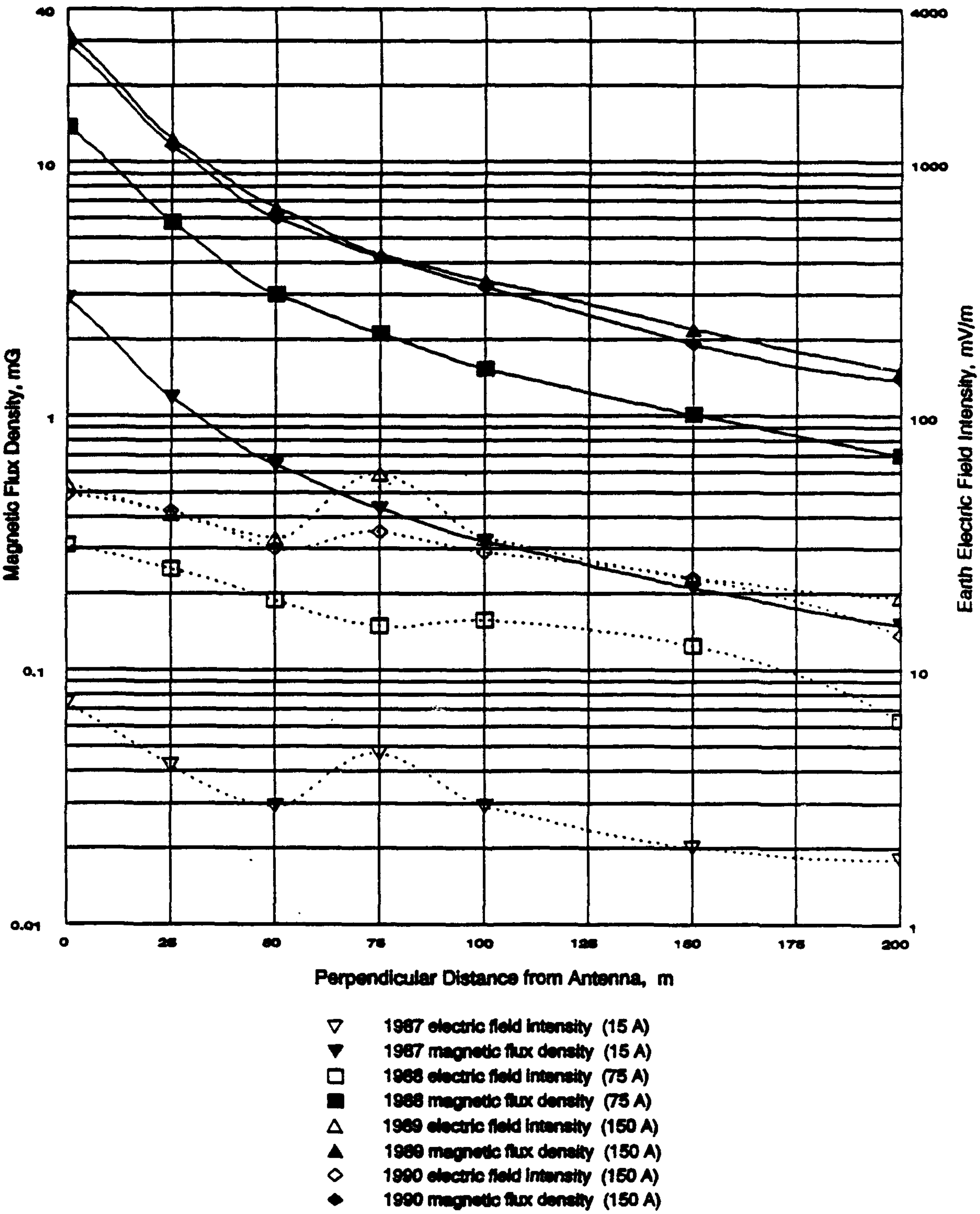



FIGURE A-31. 76 Hz MAGNETIC AND EARTH ELECTRIC FIELD PROFILES, PIRLOT ROAD; 1T1-21 THROUGH 27.

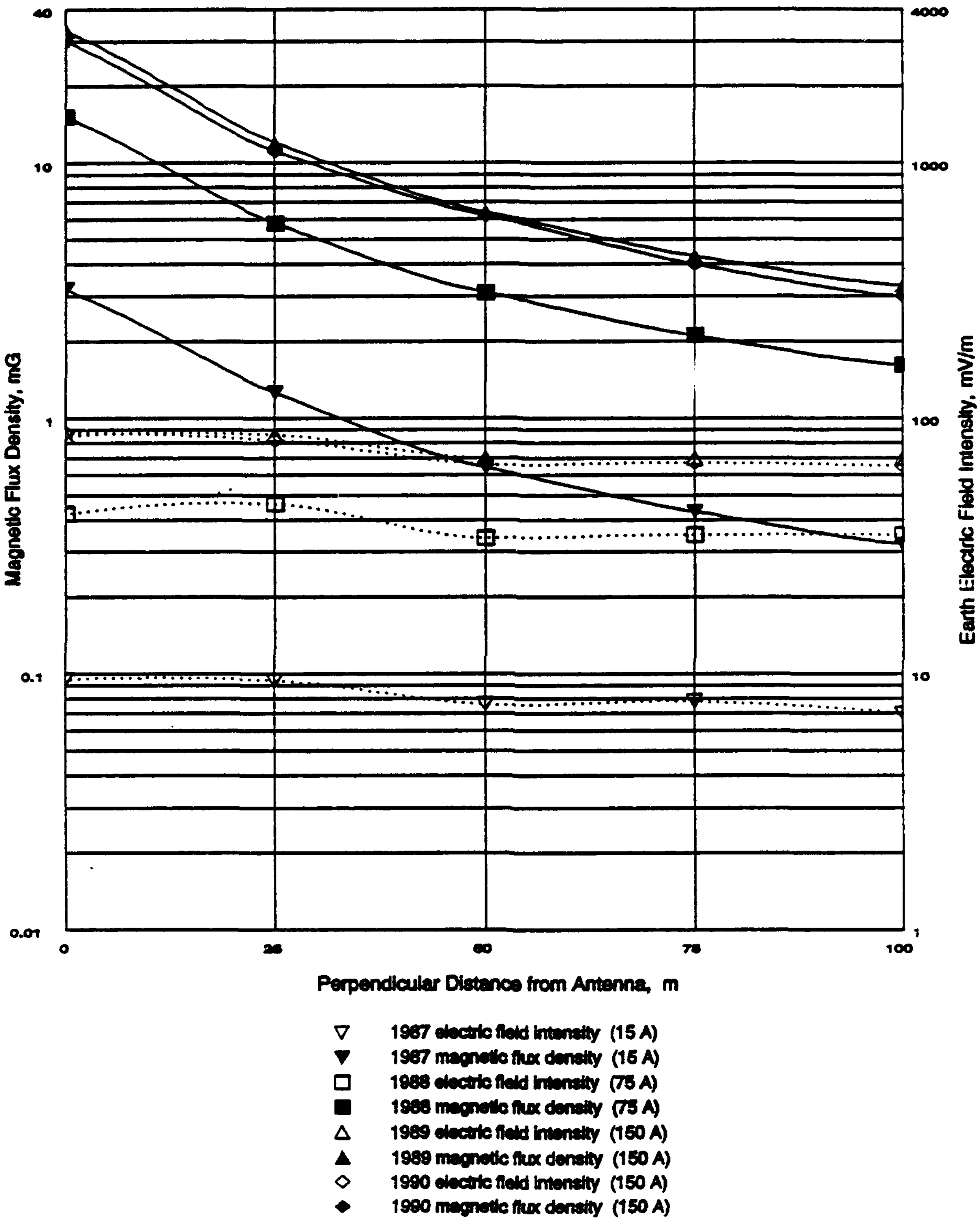



FIGURE A-32. 76 Hz MAGNETIC AND EARTH ELECTRIC FIELD PROFILES, CLEVELAND HOMESTEAD; 1T2-5 THROUGH 9.

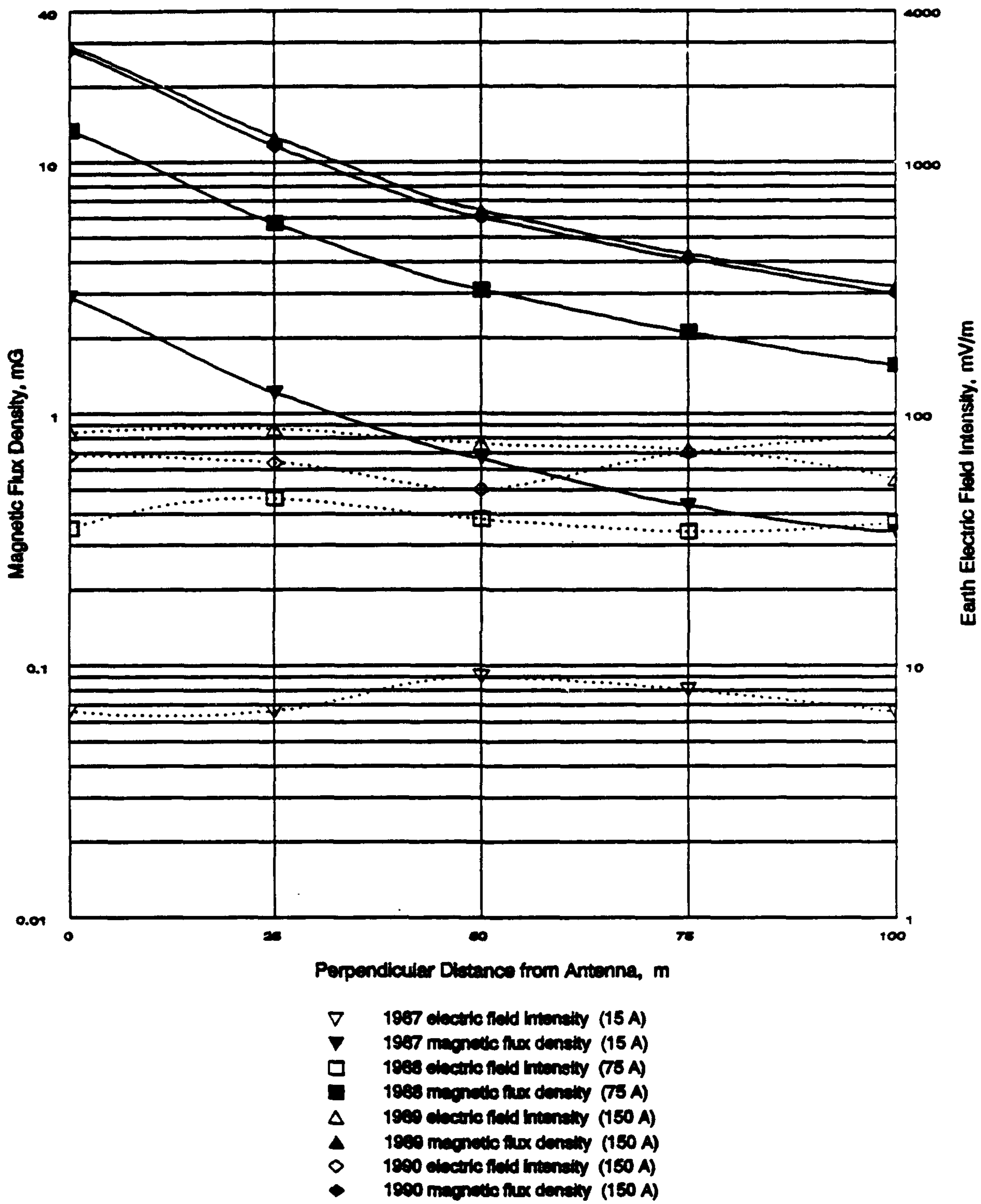



FIGURE A-33. 76 Hz MAGNETIC AND EARTH ELECTRIC FIELD PROFILES, NORTH TURNER ROAD; 1T4-5 THROUGH 9.

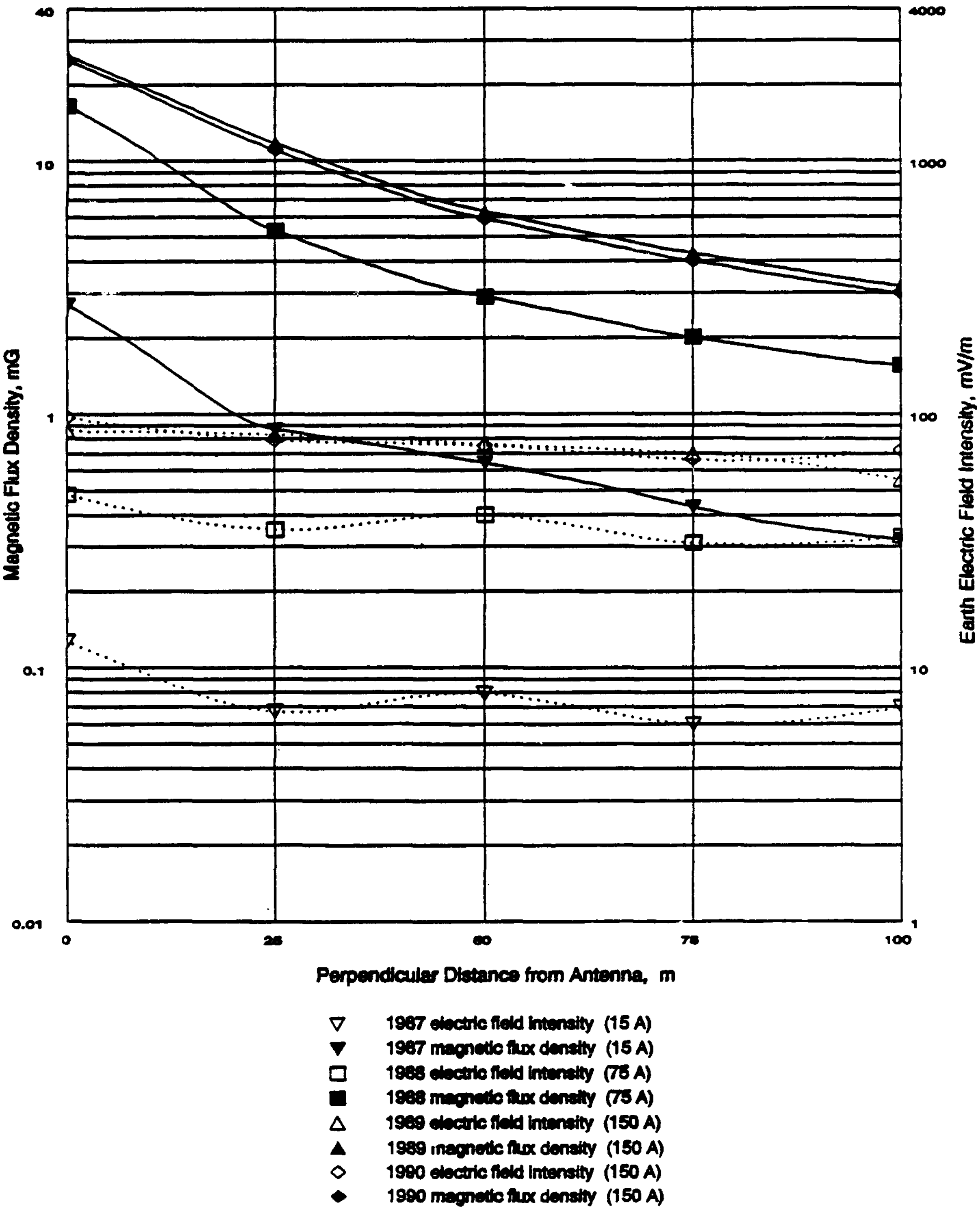



**FIGURE A-34. 76 Hz MAGNETIC AND EARTH ELECTRIC FIELD PROFILES, NORTH TURNER ROAD; 1T4-10 THROUGH 14.**

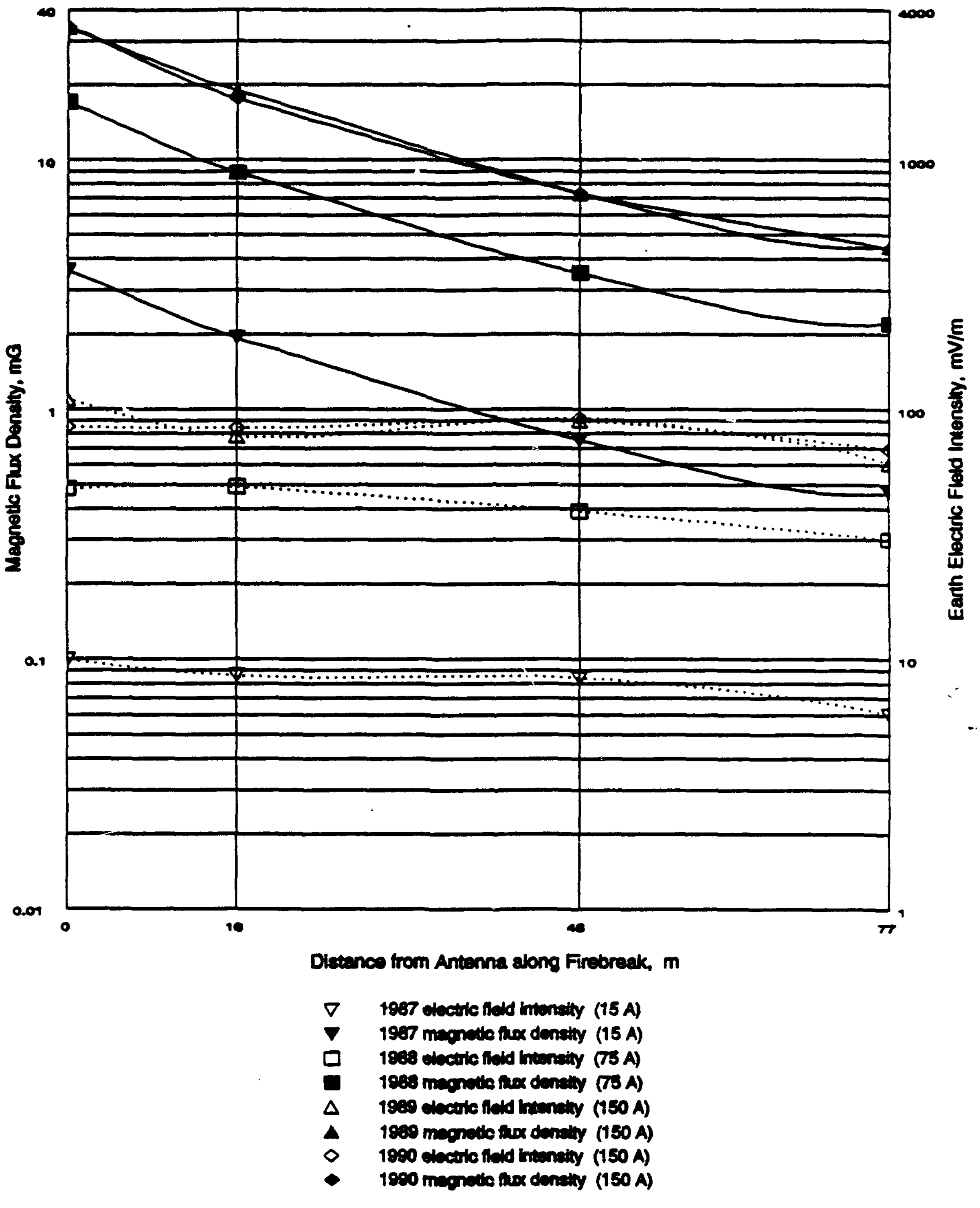



**FIGURE A-35. 76 Hz MAGNETIC AND EARTH ELECTRIC FIELD PROFILES, FORD RIVER NORTH; 1T5-1, 7, 8, 4.**

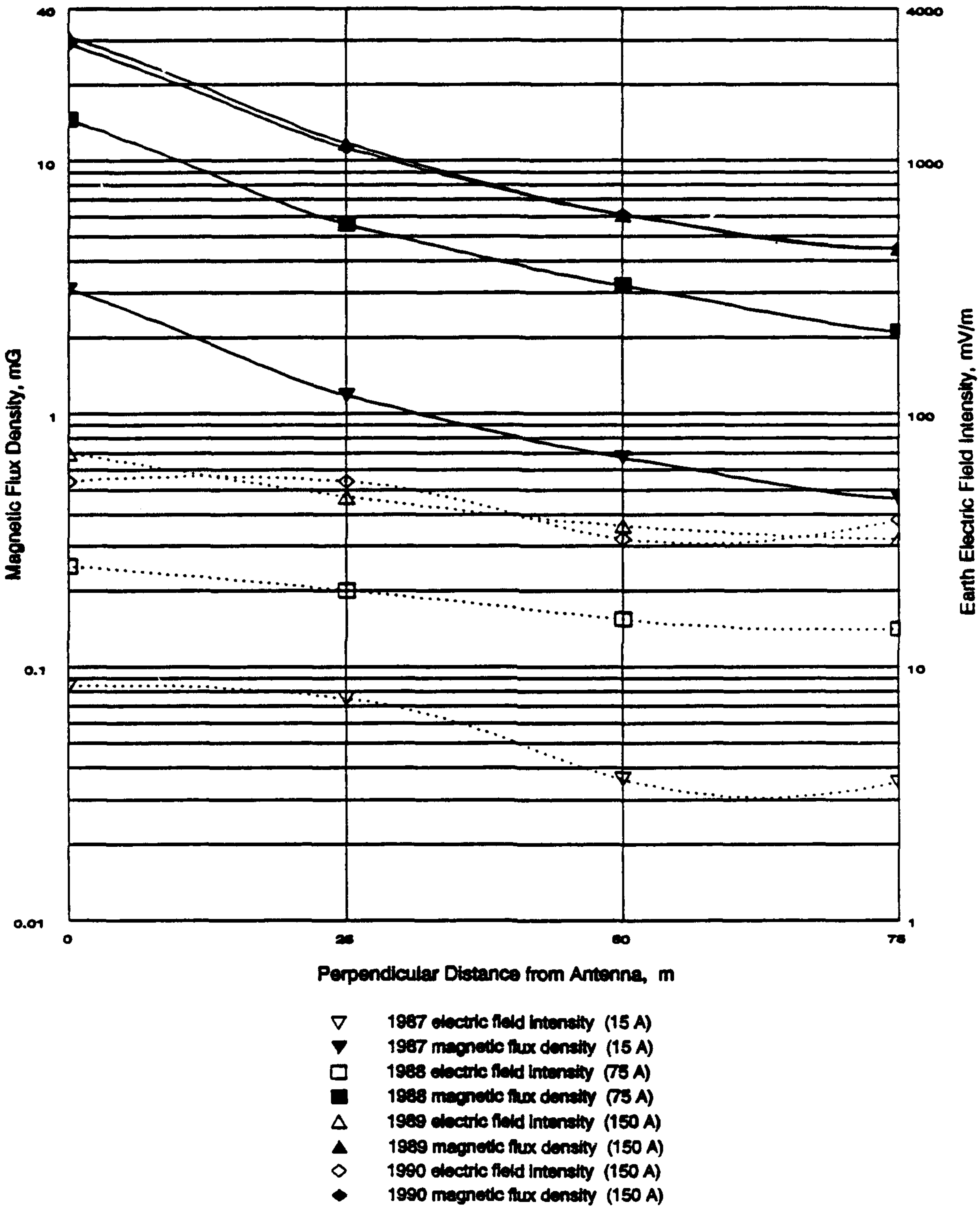



FIGURE A-36. 76 Hz MAGNETIC AND EARTH ELECTRIC FIELD PROFILES, FORD RIVER NORTH; 1T5-2, 9, 10, 6.

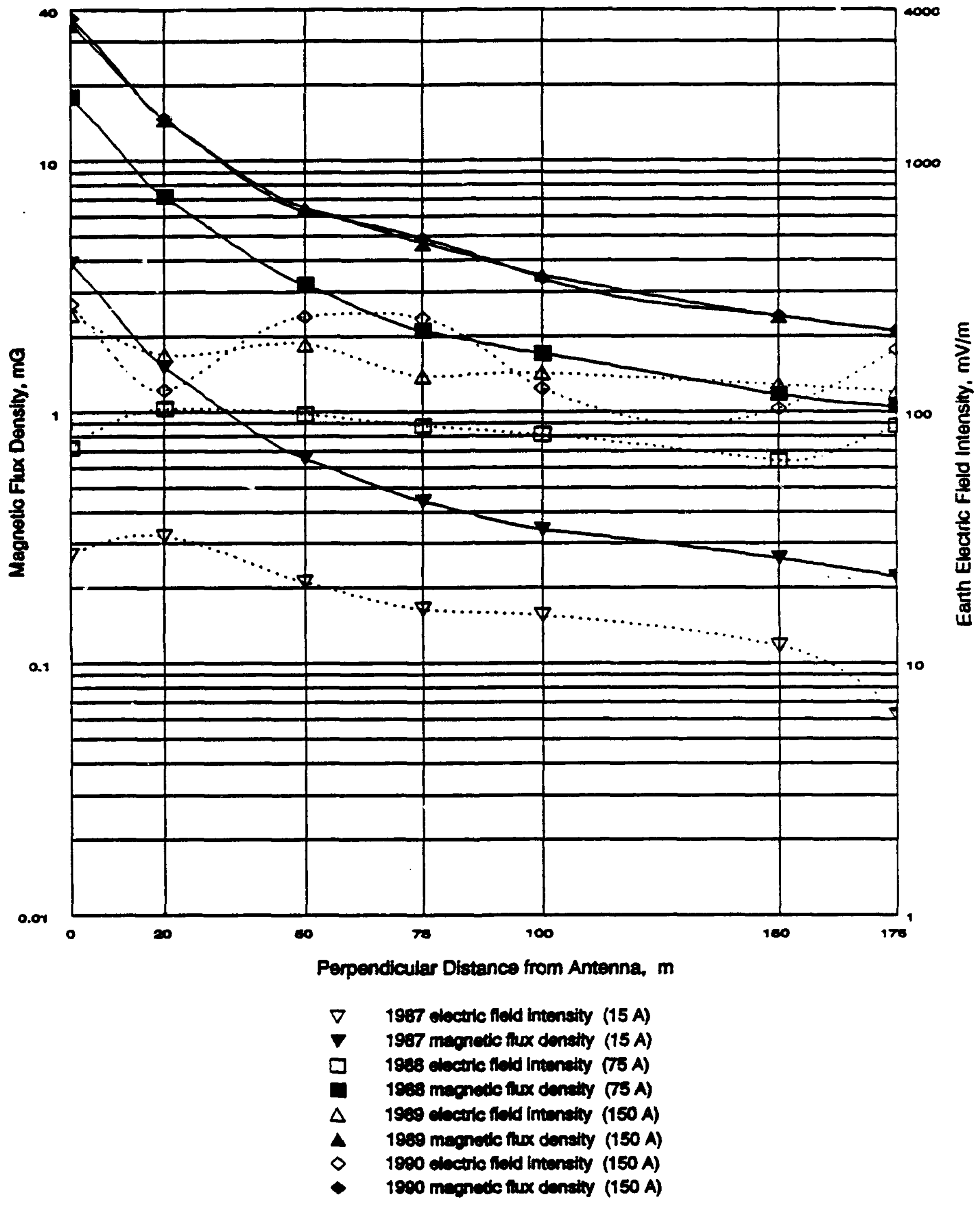



FIGURE A-37. 76 Hz MAGNETIC AND EARTH ELECTRIC FIELD PROFILES, FORD RIVER SOUTH; 1T6-2, 1, 3, 4, 5, 6, 7.

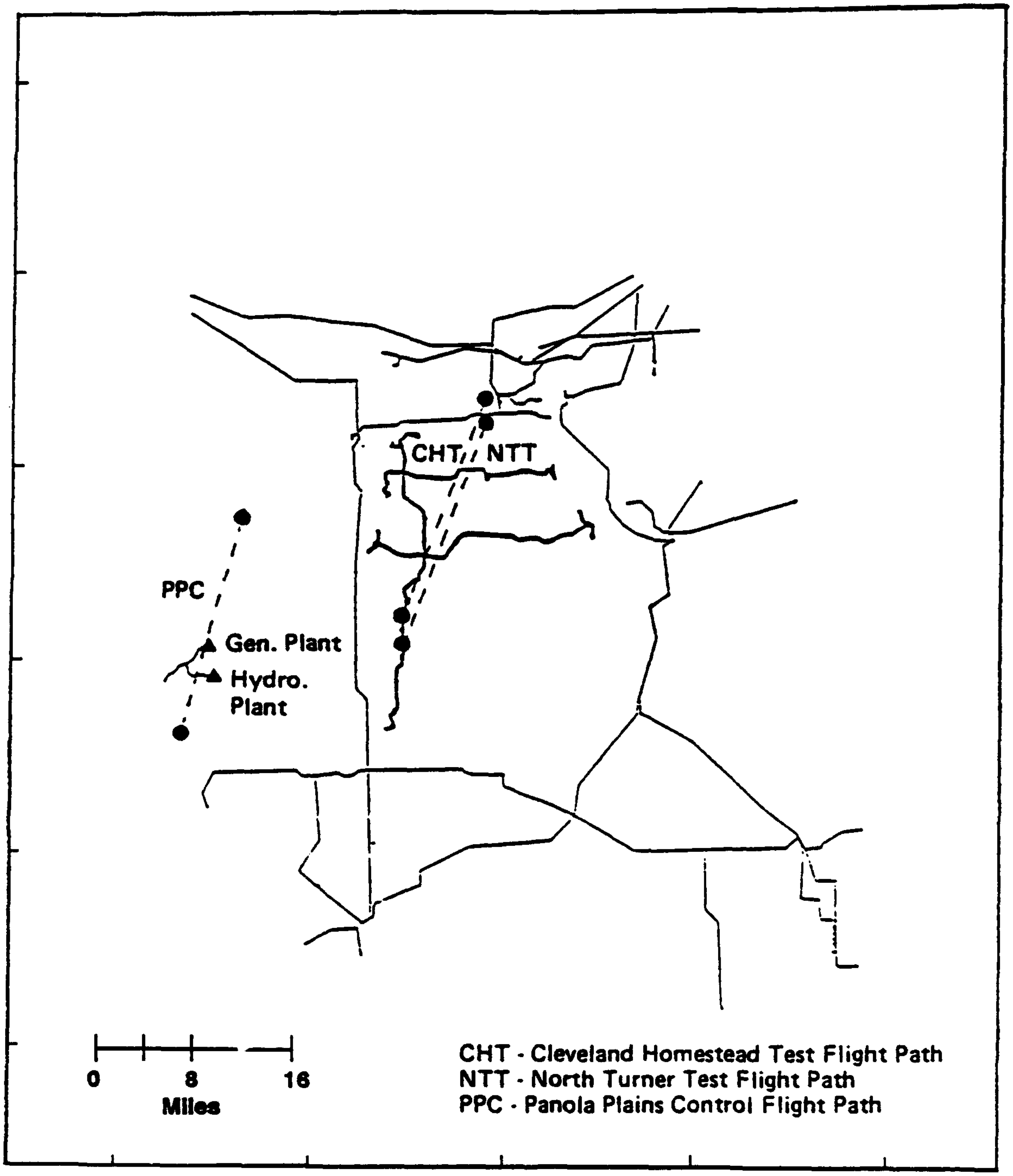



FIGURE A-38. BIRD DISPLACEMENT FLIGHT PATH LOCATIONS RELATIVE TO HIGH VOLTAGE 60 Hz TRANSMISSION LINES.

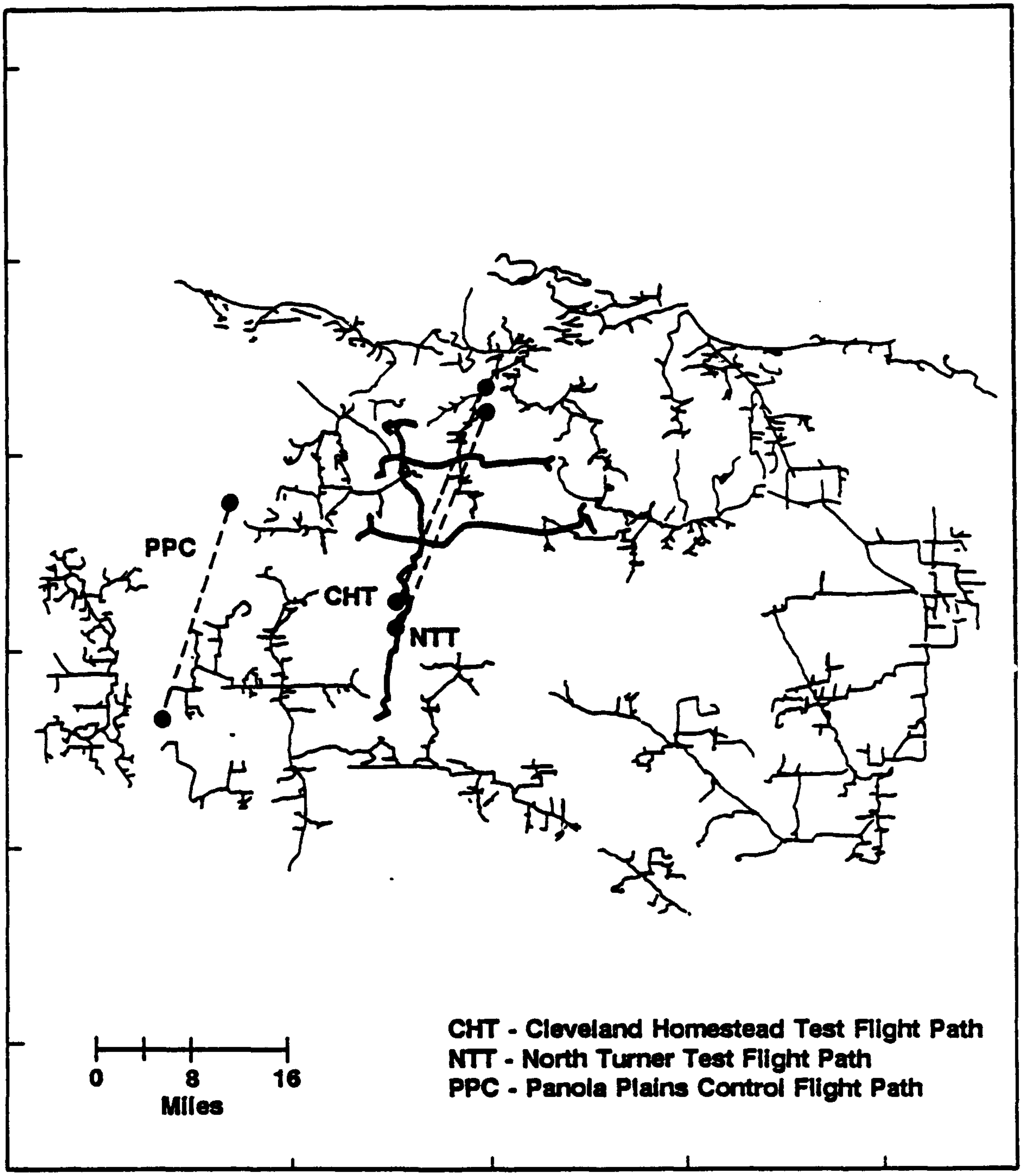



**FIGURE A-39. BIRD DISPLACEMENT FLIGHT PATH LOCATIONS RELATIVE TO 60 Hz POWER DISTRIBUTION LINES.**

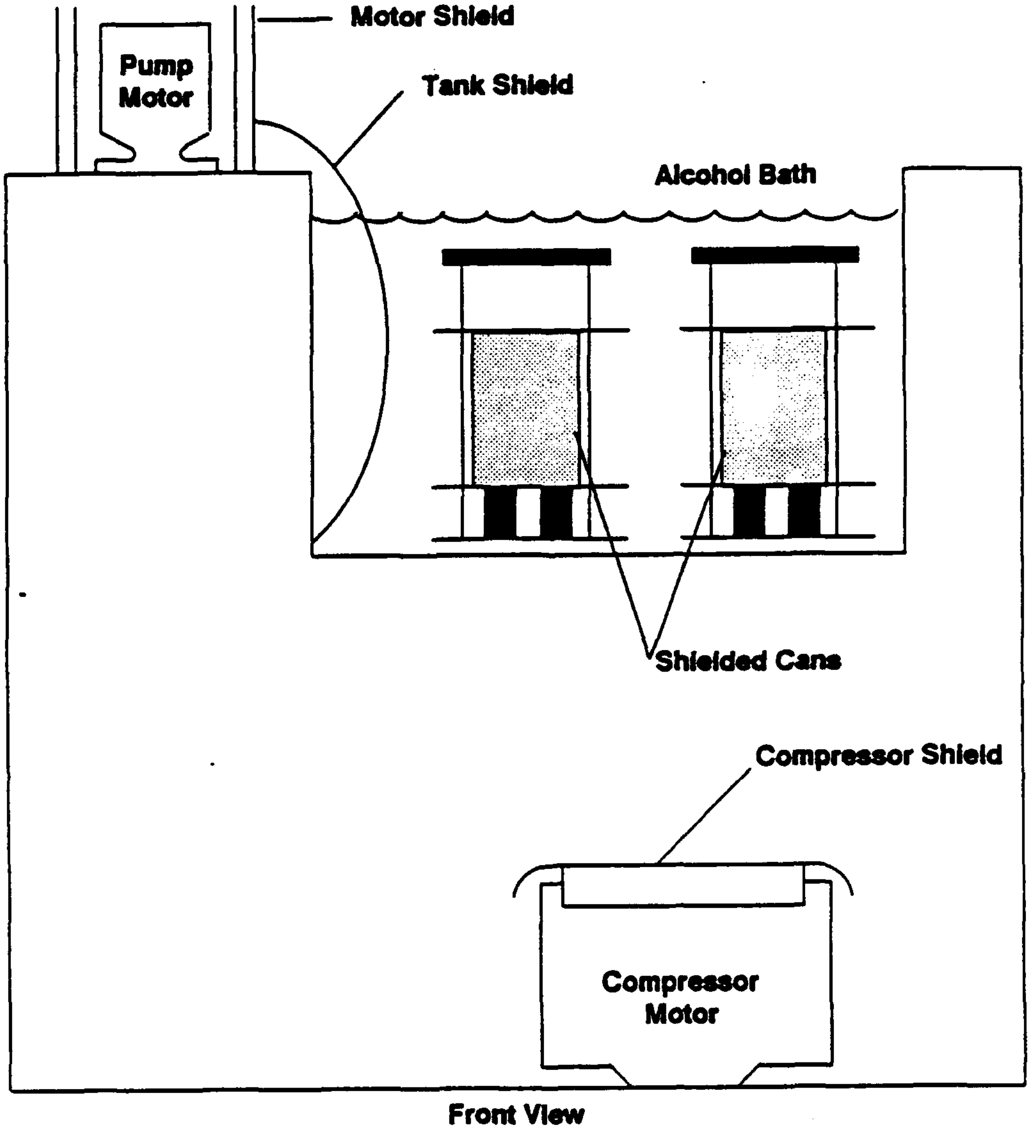



FIGURE A-40. MAGNETIC SHIELD LOCATIONS AT THE METABOLIC COOLING BATH.

TABLE A-3. 60 Hz AIR ELECTRIC FIELD INTENSITIES (V/m)
Small Mammals and Nesting Birds Studies
(page 1 of 4)

| Site No., Meas. Pt. | 1983[a] | 1984[a] | 1985[a] | 1986[b] | 1987[c] | 1988[c] | 1989[d] | 1990 |
|---|---|---|---|---|---|---|---|---|
| 1C1-2 | < | < | < | -- | -- | -- | -- | -- |
| 1C1-3 | - | - | < | < | < | < | < | <[d] |
| 1C1-4 | - | - | - | < | < | < | < | <[d] |
| 1C3-1 | < | < | < | < | < | < | < | <[d] |
| 1C3-2 | < | < | -- | -- | -- | -- | -- | -- |
| 1C3-3 | - | - | - | < | < | < | < | <[d] |
| 1C4-1 | - | 0.001 | < | < | < | < | < | <[d] |
| 1C4-2 | - | <0.001 | < | -- | -- | -- | -- | -- |
| 1C4-3 | - | <0.001 | < | < | -- | -- | -- | -- |
| 1C4-4 | - | - | < | < | < | < | < | <[d] |
| 1C4-5 | - | - | - | - | < | < | < | <[d] |
| 1D3-1 | - | - | - | < | < | < | < | <[d] |
| 1C6-1 | - | 0.001 | < | < | < | < | < | <[d] |
| 1C6-3 | - | - | < | < | < | < | < | <[d] |
| 1C6-4 | - | - | < | < | < | < | < | <[d] |
| 1L4-1 | - | - | - | - | - | < | < | <[d] |

a = antennas not constructed.
b = antennas off, grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 A current.

- = measurement point not established.
-- = measurement point dropped.
/ = measurement not taken.
# = measurement precluded by antenna operation.
< = measurement est. <0.001 V/m based on earth E-field.

TABLE A-3. 60 Hz AIR ELECTRIC FIELD INTENSITIES (V/m)
Small Mammals and Nesting Birds Studies
(page 2 of 4)

| Site No., Meas. Pt. | 1983[a] | 1984[a] | 1985[a] | 1986[b] | 1987[c] | 1988[c] | 1989[d] | 1990 |
|---|---|---|---|---|---|---|---|---|
| 1T1-1 | 0.001 | < | < | -- | -- | -- | -- | -- |
| 1T1-3 | - | < | < | -- | -- | -- | -- | -- |
| 1T1-4 | - | < | < | -- | -- | -- | -- | -- |
| 1T1-10 | - | < | < | -- | -- | -- | -- | -- |
| 1T1-12 | - | - | < | -- | -- | -- | -- | -- |
| 1T1-13 | - | - | < | -- | -- | -- | -- | -- |
| 1T1-14 | - | - | - | < | < | < | < | <[b] |
| 1T1-15 | - | - | - | < | < | < | # | <[b] |
| 1T1-16 | - | - | - | < | < | < | # | <[b] |
| 1T1-17 | - | - | - | < | < | < | # | <[b] |
| 1T1-18 | - | - | - | < | < | < | # | <[b] |
| 1T1-19 | - | - | - | < | < | < | # | <[b] |
| 1T1-20 | - | - | - | < | < | < | # | <[b] |
| 1T1-28 | - | - | - | - | - | < | # | <[b] |
| 1T1-29 | - | - | - | - | - | < | # | <[b] |
| 1T1-30 | - | - | - | - | - | < | # | <[b] |
| 1T1-31 | - | - | - | - | - | < | # | <[b] |
| 1T1-21 | - | - | - | < | 0.086 | 0.49 | 0.109 | 0.076[b] |
| 1T1-22 | - | - | - | < | <0.001 | < | <0.001 | <0.001[b] |
| 1T1-23 | - | - | - | < | < | < | <0.001 | <[b] |
| 1T1-24 | - | - | - | < | < | < | < | <[b] |
| 1T1-25 | - | - | - | < | < | < | < | <[b] |
| 1T1-26 | - | - | - | < | < | < | < | <[b] |
| 1T1-27 | - | - | - | < | < | < | < | <[b] |

a = antennas not constructed.
b = antennas off, grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 A current.

- = measurement point not established.
-- = measurement point dropped.
/ = measurement not taken.
# = measurement precluded by antenna operation.
< = measurement est. <0.001 V/m based on earth E-field.

TABLE A-3. 60 Hz AIR ELECTRIC FIELD INTENSITIES (V/m)
Small Mammals and Nesting Birds Studies
(page 3 of 4)

| Site No., Meas. Pt. | 1983[a] | 1984[a] | 1985[a] | 1986[b] | 1987[c] | 1988[c] | 1989[d] | 1990 |
|---|---|---|---|---|---|---|---|---|
| 1T2-1 | <0.001 | 0.001 | < | < | -- | -- | -- | -- |
| 1T2-2 | - | - | - | < | -- | -- | -- | -- |
| 1T2-3 | - | - | - | < | -- | -- | -- | -- |
| 1T2-4 | - | - | - | < | -- | -- | -- | -- |
| 1T2-5 | - | - | - | - | 0.198 | 0.053 | 0.016 | 0.070[c] |
| 1T2-6 | - | - | - | - | 0.024 | 0.007 | 0.002 | 0.010[c] |
| 1T2-7 | - | - | - | - | 0.005 | < | < | 0.002[c] |
| 1T2-8 | - | - | - | - | 0.002 | < | < | 0.001[c] |
| 1T2-9 | - | - | - | - | <0.001 | < | < | <0.001[c] |
| 1D1-1 | - | - | - | 2.5 | 2.0 | 9.2 | 0.74 | 1.35[d] |
| 1T4-1 | - | <0.001 | < | -- | -- | -- | -- | -- |
| 1T4-3 | - | - | < | -- | -- | -- | -- | -- |
| 1T4-4 | - | - | < | -- | -- | -- | -- | -- |
| 1T4-5 | - | - | - | < | 0.094 | 0.066 | 0.004 | 0.155[c] |
| 1T4-6 | - | - | - | < | 0.014 | 0.014 | 0.003 | 0.037[c] |
| 1T4-7 | - | - | - | < | 0.004 | 0.002 | <0.001 | 0.007[c] |
| 1T4-8 | - | - | - | < | <0.001 | <0.001 | < | 0.002[c] |
| 1T4-9 | - | - | - | < | < | < | < | <0.001[c] |
| 1T4-10 | - | - | - | - | 0.062 | 0.041 | 0.009 | 0.078[c] |
| 1T4-11 | - | - | - | - | 0.014 | 0.006 | 0.002 | 0.020[c] |
| 1T4-12 | - | - | - | - | 0.004 | 0.003 | < | 0.005[c] |
| 1T4-13 | - | - | - | - | 0.002 | 0.002 | < | 0.003[c] |
| 1T4-14 | - | - | - | - | 0.001 | 0.001 | < | 0.001[c] |

a = antennas not constructed.
b = antennas off, grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 A current.

\- = measurement point not established.
-- = measurement point dropped.
/ = measurement not taken.
# = measurement precluded by antenna operation.
< = measurement est. <0.001 V/m based on earth E-field.

TABLE A-3. 60 Hz AIR ELECTRIC FIELD INTENSITIES (V/m)
Small Mammals and Nesting Birds Studies
(page 4 of 4)

| Site No., Meas. Pt. | 1983[a] | 1984[a] | 1985[a] | 1986[b] | 1987[c] | 1988[c] | 1989[d] | 1990 |
|---|---|---|---|---|---|---|---|---|
| 1D2-1 | - | - | - | < | < | < | 0.004 | 0.005[d] |
| 1T5-1 | - | <0.001 | < | < | 0.118 | 0.157 | # | 0.29[c] |
| 1T5-7 | - | - | - | - | 0.019 | 0.019 | # | 0.067[c] |
| 1T5-8 | - | - | - | - | <0.001 | < | # | <0.001[c] |
| 1T5-4 | - | - | - | < | < | < | # | <0.001[c] |
| 1T5-2 | <0.001 | <0.001 | < | < | 0.074 | 0.130 | # | 0.043[b] |
| 1T5-9 | - | - | - | - | 0.014 | 0.017 | # | 0.006[b] |
| 1T5-10 | - | - | - | - | 0.002 | 0.004 | # | 0.001[b] |
| 1T5-6 | - | - | - | < | <0.001 | < | # | <0.001[b] |
| 1T5-3 | - | - | - | < | -- | -- | -- | -- |
| 1T5-5 | - | - | - | < | <0.001 | 0.001 | # | <0.001[b] |
| 1T6-2 | - | - | - | - | 0.162 | 0.46 | # | 0.141,0.3[b,c] |
| 1T6-1 | <0.001 | <0.001,0.001 | < | < | 0.024 | 0.079 | # | 0.024,0.048[b,c] |
| 1T6-3 | - | - | - | - | 0.003 | 0.003 | # | <0.001[b,c] |
| 1T6-4 | - | - | - | - | 0.001 | 0.003 | # | <[b,c] |
| 1T6-5 | - | - | - | - | 0.001 | 0.002 | # | <[b,c] |
| 1T6-6 | - | - | - | - | 0.001 | <0.001 | # | <[b] |
| 1T6-7 | - | - | - | - | <0.001 | <0.001 | # | <[b] |

a = antennas not constructed.
b = antennas off, grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 A current.

\- = measurement point not established.
-- = measurement point dropped.
/ = measurement not taken.
# = measurement precluded by antenna operation.
< = measurement est. <0.001 V/m based on earth E-field.

TABLE A-4. 60 Hz EARTH ELECTRIC FIELD INTENSITIES (mV/m)
Small Mammals and Nesting Birds Studies
(page 1 of 6)

| Site No., Meas. Pt. | 1983[a] | 1984[a] | 1985[a] | 1986[b] | 1987[c] | 1988[c] | 1989[d] | 1990 |
|---|---|---|---|---|---|---|---|---|
| 1C1-2 | 0.041 | 0.146 | 0.056 | -- | -- | -- | -- | -- |
| 1C1-3 | - | - | 0.128 | 0.082 | 0.114 | 0.59 | 0.053 | 0.046[d] |
| 1C1-4 | - | - | - | 0.117 | 0.114 | 0.085 | 0.22 | 0.066[d] |
| 1C3-1 | 0.106 | 0.26 | 0.133 | 0.086 | 0.118 | 0.085 | 0.135 | 0.056[d] |
| 1C3-2 | 0.125 | 0.191 | / | -- | -- | -- | -- | -- |
| 1C3-3 | - | - | - | 0.074 | 0.178 | 0.148 | 0.22 | 0.163[d] |
| 1C4-1 | - | 0.028,0.030 | 0.045 | 0.065 | 0.093 | 0.087 | 0.041 | 0.032[d] |
| 1C4-2 | - | 0.019,0.023 | 0.015 | -- | -- | -- | -- | -- |
| 1C4-3 | - | 0.036,0.065 | 0.103 | 0.118 | -- | -- | -- | -- |
| 1C4-4 | - | - | 0.009,0.017 | 0.011 | 0.011 | 0.011 | 0.010 | 0.016[d] |
| 1C4-5 | - | - | - | - | 0.037 | 0.046 | 0.021 | 0.018[d] |
| 1D3-1 | - | - | - | 0.052 | 0.156 | 0.053 | 0.29 | 0.26[d] |
| 1C6-1 | - | 0.072 | 0.095 | 0.088 | 0.106 | 0.057 | 0.102 | 0.103[d] |
| 1C6-3 | - | - | 0.123 | 0.109 | 0.141 | 0.053 | 0.122 | 0.075[d] |
| 1C6-4 | - | - | 0.038 | 0.007 | 0.020 | 0.013 | 0.013 | 0.021[d] |
| 1L4-1 | - | - | - | - | - | 0.019 | 0.013 | 0.022[d] |

a = antennas not constructed.
b = antennas off, grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 A current.

\- = measurement point not established.
-- = measurement point dropped.
/ = measurement not taken.
# = measurement precluded by antenna operation.

TABLE A-4. 60 Hz EARTH ELECTRIC FIELD INTENSITIES (mV/m)
Small Mammals and Nesting Birds Studies
(page 2 of 4)

| Site No., Meas. Pt. | 1983[a] | 1984[a] | 1985[a] | 1986[b] | 1987[c] | 1988[c] | 1989[d] | 1990 |
|---|---|---|---|---|---|---|---|---|
| 1T1-1 | 0.090 | 0.091 | 0.131 | -- | -- | -- | -- | -- |
| 1T1-3 | - | 0.21 | 0.179 | -- | -- | -- | -- | -- |
| 1T1-4 | - | 0.174 | 0.171 | -- | -- | -- | -- | -- |
| 1T1-10 | - | 0.097 | 0.147 | -- | -- | -- | -- | -- |
| 1T1-12 | - | - | 0.033 | -- | -- | -- | -- | -- |
| 1T1-13 | - | - | 0.034 | -- | -- | -- | -- | -- |
| 1T1-14 | - | - | - | 0.102 | 0.058 | 0.29 | 0.071 | 0.071[b] |
| 1T1-15 | - | - | - | 0.040 | 0.029 | 0.064 | # | 0.025[b] |
| 1T1-16 | - | - | - | 0.115 | 0.102 | 0.40 | # | 0.179[b] |
| 1T1-17 | - | - | - | 0.118 | 0.128 | 0.37 | # | 0.102[b] |
| 1T1-18 | - | - | - | 0.100 | 0.104 | 0.46 | # | 0.081[b] |
| 1T1-19 | - | - | - | 0.112 | 0.132 | 0.43 | # | 0.101[b] |
| 1T1-20 | - | - | - | 0.118 | 0.123 | 0.43 | # | 0.099[b] |
| 1T1-28 | - | - | - | - | - | 0.018 | # | 0.100[b] |
| 1T1-29 | - | - | - | - | - | 0.014 | # | 0.078[b] |
| 1T1-30 | - | - | - | - | - | 0.019 | # | 0.066[b] |
| 1T1-31 | - | - | - | - | - | 0.022 | # | 0.068[b] |
| 1T1-21 | - | - | - | 0.082 | 0.082 | 0.53 | 0.113 | 0.060[b] |
| 1T1-22 | - | - | - | 0.050 | 0.047 | 0.40 | 0.086 | 0.049[b] |
| 1T1-23 | - | - | - | 0.037 | 0.037 | 0.31 | 0.068 | 0.024[b] |
| 1T1-24 | - | - | - | 0.042 | 0.058 | 0.23 | 0.126 | 0.040[b] |
| 1T1-25 | - | - | - | 0.033 | 0.035 | 0.26 | 0.070 | 0.034[b] |
| 1T1-26 | - | - | - | 0.022 | 0.025 | 0.20 | 0.052 | 0.023[b] |
| 1T1-27 | - | - | - | 0.014 | 0.021 | 0.094 | 0.056 | 0.015[b] |

a = antennas not constructed.
b = antennas off, grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 A current.

- = measurement point not established.
-- = measurement point dropped.
/ = measurement not taken.
# = measurement precluded by antenna operation.

TABLE A-4. 60 Hz EARTH ELECTRIC FIELD INTENSITIES (mV/m)
Small Mammals and Nesting Birds Studies
(page 3 of 4)

| Site No., Meas. Pt. | 1983[a] | 1984[a] | 1985[a] | 1986[b] | 1987[c] | 1988[c] | 1989[d] | 1990 |
|---|---|---|---|---|---|---|---|---|
| 1T2-1 | 0.170 | 0.22 | 0.197 | 0.122 | -- | -- | -- | -- |
| 1T2-2 | - | - | - | 0.047 | -- | -- | -- | -- |
| 1T2-3 | - | - | - | 0.083 | -- | -- | -- | -- |
| 1T2-4 | - | - | - | 0.044 | -- | -- | -- | -- |
| 1T2-5 | - | - | - | - | 0.074 | 0.074 | 0.047 | 0.035[c] |
| 1T2-6 | - | - | - | - | 0.069 | 0.087 | 0.064 | 0.064[c] |
| 1T2-7 | - | - | - | - | 0.047 | 0.062 | 0.040 | 0.044[c] |
| 1T2-8 | - | - | - | - | 0.051 | 0.067 | 0.055 | 0.047[c] |
| 1T2-9 | - | - | - | - | 0.055 | 0.087 | 0.031 | 0.044[c] |
| 1D1-1 | - | - | - | 9.6 | 2.4 | 1.15 | 2.7 | 1.96[d] |
| 1T4-1 | - | 0.178,0.184 | 0.150 | -- | -- | -- | -- | -- |
| 1T4-3 | - | - | 0.22 | -- | -- | -- | -- | -- |
| 1T4-4 | - | - | 0.131 | -- | -- | -- | -- | -- |
| 1T4-5 | - | - | - | 0.052 | 0.081 | 0.135 | 0.035 | 0.147[c] |
| 1T4-6 | - | - | - | 0.104 | 0.066 | 0.128 | 0.039 | 0.106[c] |
| 1T4-7 | - | - | - | 0.102 | 0.090 | 0.128 | 0.036 | 0.126[c] |
| 1T4-8 | - | - | - | 0.082 | 0.078 | 0.096 | 0.032 | 0.186[c] |
| 1T4-9 | - | - | - | 0.088 | 0.063 | 0.098 | 0.032 | 0.200[c] |
| 1T4-10 | - | - | - | - | 0.135 | 0.124 | 0.126 | 0.22[c] |
| 1T4-11 | - | - | - | - | 0.071 | 0.089 | 0.047 | 0.191[c] |
| 1T4-12 | - | - | - | - | 0.071 | 0.100 | 0.041 | 0.181[c] |
| 1T4-13 | - | - | - | - | 0.063 | 0.083 | 0.037 | 0.161[c] |
| 1T4-14 | - | - | - | - | 0.068 | 0.121 | 0.037 | 0.148[c] |

a = antennas not constructed.
b = antennas off, grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 A current.

- = measurement point not established.
-- = measurement point dropped.
/ = measurement not taken.
# = measurement precluded by antenna operation.

TABLE A-4. 60 Hz EARTH ELECTRIC FIELD INTENSITES (mV/m)
Small Mammals and Nesting Birds Studies
(page 4 of 4)

| Site No., Meas. Pt. | 1983[a] | 1984[a] | 1985[a] | 1986[b] | 1987[c] | 1988[c] | 1989[d] | 1990 |
|---|---|---|---|---|---|---|---|---|
| 1D2-1 | - | - | - | 0.47 | 0.160 | 0.28 | 0.69 | 0.59[d] |
| 1T5-1 | - | 0.24,0.42 | 0.25 | 0.115 | 0.128 | 0.34 | # | 0.41[c] |
| 1T5-7 | - | - | - | - | 0.107 | 0.33 | # | 0.37[c] |
| 1T5-8 | - | - | - | - | 0.099 | 0.23 | # | 0.37[c] |
| 1T5-4 | - | - | - | 0.061 | 0.073 | 0.166 | # | 0.26[c] |
| 1T5-2 | 0.23 | 0.26 | 0.22 | 0.042 | 0.092 | 0.108 | # | 0.062[b] |
| 1T5-9 | - | - | - | - | 0.080 | 0.089 | # | 0.054[b] |
| 1T5-10 | - | - | - | - | 0.036 | 0.056 | # | 0.030[b] |
| 1T5-6 | - | - | - | 0.051 | 0.034 | 0.053 | # | 0.024[b] |
| 1T5-3 | - | - | - | 0.125 | -- | -- | -- | -- |
| 1T5-5 | - | - | - | 0.077 | 0.051 | 0.059 | # | 0.052[b] |
| 1T6-2 | - | - | - | - | 0.48 | 1.52 | # | 0.29,0.70[b,c] |
| 1T6-1 | 0.071 | 0.65-0.88 | 0.86,0.88 | 0.23 | 0.54 | 1.49 | # | 0.39,0.90[b,c] |
| 1T6-3 | - | - | - | - | 0.32 | 1.54 | # | 0.31,0.83[b,c] |
| 1T6-4 | - | - | - | - | 0.25 | 1.32 | # | 0.25,0.44[b,c] |
| 1T6-5 | - | - | - | - | 0.21 | 1.19 | # | 0.21,0.63[b,c] |
| 1T6-6 | - | - | - | - | 0.178 | 0.90 | # | 0.169[b] |
| 1T6-7 | - | - | - | - | 0.100 | 1.31 | # | 0.20[b] |

a = antennas not constructed.
b = antennas off, grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 A current.

- = measurement point not established.
-- = measurement point dropped.
/ = measurement not taken.
# = measurement precluded by antenna operation.

TABLE A-5. 60 Hz MAGNETIC FLUX DENSITIES (mG)
Small Mammals and Nesting Birds Studies
(page 1 of 4)

| Site No., Meas. Pt. | 1983[a] | 1984[a] | 1985[a] | 1986[b] | 1987[c] | 1988[c] | 1989[d] | 1990 |
|---|---|---|---|---|---|---|---|---|
| 1C1-2 | <0.001 | 0.001 | 0.001 | -- | -- | -- | -- | -- |
| 1C1-3 | - | - | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001[d] |
| 1C1-4 | - | - | - | 0.001 | 0.001 | 0.001 | 0.001 | 0.001[d] |
| 1C3-1 | <0.001 | 0.002 | 0.002 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001[d] |
| 1C3-2 | 0.001 | 0.003 | / | -- | -- | -- | -- | -- |
| 1C3-3 | - | - | - | 0.001 | 0.001 | 0.001 | 0.001 | 0.001[d] |
| 1C4-1 | - | <0.001,0.001 | 0.001 | 0.001 | 0.002 | 0.001 | 0.001 | 0.001[d] |
| 1C4-2 | - | 0.002 | 0.002 | -- | -- | -- | -- | -- |
| 1C4-3 | - | <0.001,0.002 | <0.001 | 0.001 | -- | -- | -- | -- |
| 1C4-4 | - | - | 0.003 | 0.002 | 0.002 | 0.001 | 0.001 | 0.002[d] |
| 1C4-5 | - | - | - | - | 0.001 | 0.002 | 0.001 | 0.002[d] |
| 1D3-1 | - | - | - | 0.003 | 0.002 | 0.002 | 0.013 | 0.009[d] |
| 1C6-1 | - | 0.003 | 0.003 | 0.002 | <0.001 | 0.002 | 0.003 | 0.002[d] |
| 1C6-3 | - | - | 0.003 | 0.003 | 0.003 | 0.002 | 0.002 | 0.003[d] |
| 1C6-4 | - | - | 0.003 | 0.003 | 0.004 | 0.003 | 0.003 | 0.004[d] |
| 1L4-1 | - | - | - | - | - | 0.003 | 0.002 | 0.002[d] |

a = antennas not constructed.
b = antennas off, grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 A current.

\- = measurement point not established.
-- = measurement point dropped.
/ = measurement not taken.
# = measurement precluded by antenna operation.

TABLE A-5. 60 Hz MAGNETIC FLUX DENSITIES (mG)
Small Mammals and Nesting Birds Studies
(page 2 of 4)

| Site No., Meas. Pt. | 1983[a] | 1984[a] | 1985[a] | 1986[b] | 1987[c] | 1988[c] | 1989[d] | 1990 |
|---|---|---|---|---|---|---|---|---|
| 1T1-1 | 0.002 | 0.002 | 0.002 | -- | -- | -- | -- | -- |
| 1T1-3 | - | 0.002 | 0.002 | -- | -- | -- | -- | -- |
| 1T1-4 | - | 0.002 | 0.002 | -- | -- | -- | -- | -- |
| 1T1-10 | - | 0.004 | 0.003 | -- | -- | -- | -- | -- |
| 1T1-12 | - | - | 0.004 | -- | -- | -- | -- | -- |
| 1T1-13 | - | - | 0.005 | -- | -- | -- | -- | -- |
| 1T1-14 | - | - | - | 0.004 | 0.003 | 0.014 | 0.003 | 0.002[b] |
| 1T1-15 | - | - | - | 0.004 | 0.004 | 0.009 | # | 0.003[b] |
| 1T1-16 | - | - | - | 0.009 | 0.006 | 0.22 | # | 0.009[b] |
| 1T1-17 | - | - | - | 0.007 | 0.009 | 0.031 | # | 0.007[b] |
| 1T1-18 | - | - | - | 0.006 | 0.008 | 0.028 | # | 0.006[b] |
| 1T1-19 | - | - | - | 0.001 | 0.009 | 0.032 | # | 0.007[b] |
| 1T1-20 | - | - | - | 0.008 | 0.011 | 0.034 | # | 0.008[b] |
| 1T1-28 | - | - | - | - | - | 0.001 | # | 0.006[b] |
| 1T1-29 | - | - | - | - | - | 0.001 | # | 0.006[b] |
| 1T1-30 | - | - | - | - | - | 0.001 | # | 0.006[b] |
| 1T1-31 | - | - | - | - | - | 0.001 | # | 0.006[b] |
| 1T1-21 | - | - | - | 0.055 | 0.042 | 0.29 | 0.072 | 0.036[b] |
| 1T1-22 | - | - | - | 0.012 | 0.018 | 0.108 | 0.029 | 0.014[b] |
| 1T1-23 | - | - | - | 0.008 | 0.011 | 0.060 | 0.015 | 0.006[b] |
| 1T1-24 | - | - | - | 0.005 | 0.008 | 0.041 | 0.008 | 0.006[b] |
| 1T1-25 | - | - | - | 0.005 | 0.005 | 0.030 | 0.007 | 0.004[b] |
| 1T1-26 | - | - | - | 0.003 | 0.004 | 0.021 | 0.005 | 0.003[b] |
| 1T1-27 | - | - | - | 0.002 | 0.003 | 0.014 | 0.004 | 0.002[b] |

a = antennas not constructed.
b = antennas off, grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 A current.

\- = measurement point not established.
-- = measurement point dropped.
/ = measurement not taken.
# = measurement precluded by antenna operation.

TABLE A-5. 60 Hz MAGNETIC FLUX DENSITIES (mG)
Small Mammals and Nesting Birds Studies
(page 3 of 4)

| Site No., Meas. Pt. | 1983[a] | 1984[a] | 1985[a] | 1986[b] | 1987[c] | 1988[c] | 1989[d] | 1990 |
|---|---|---|---|---|---|---|---|---|
| 1T2-1 | <0.001 | 0.001 | 0.001 | 0.077 | -- | -- | -- | -- |
| 1T2-2 | - | - | - | 0.009 | -- | -- | -- | -- |
| 1T2-3 | - | - | - | 0.006 | -- | -- | -- | -- |
| 1T2-4 | - | - | - | 0.006 | -- | -- | -- | -- |
| 1T2-5 | - | - | - | - | 0.050 | 0.023 | 0.017 | 0.051[c] |
| 1T2-6 | - | - | - | - | 0.018 | 0.011 | 0.006 | 0.019[c] |
| 1T2-7 | - | - | - | - | 0.009 | 0.007 | 0.003 | 0.010[c] |
| 1T2-8 | - | - | - | - | 0.006 | 0.005 | 0.002 | 0.007[c] |
| 1T2-9 | - | - | - | - | 0.005 | 0.006 | 0.002 | 0.005[c] |
| 1D1-1 | - | - | - | 0.109 | 0.154 | 0.040 | 0.151 | 0.141[d] |
| 1T4-1 | - | 0.001 | 0.001 | -- | -- | -- | -- | -- |
| 1T4-3 | - | - | 0.001 | -- | -- | -- | -- | -- |
| 1T4-4 | - | - | 0.001 | -- | -- | -- | -- | -- |
| 1T4-5 | - | - | - | 0.021 | 0.060 | 0.061 | 0.010 | 0.090[c] |
| 1T4-6 | - | - | - | 0.019 | 0.024 | 0.017 | 0.004 | 0.038[c] |
| 1T4-7 | - | - | - | 0.011 | 0.013 | 0.010 | 0.003 | 0.020[c] |
| 1T4-8 | - | - | - | 0.006 | 0.008 | 0.005 | 0.001 | 0.014[c] |
| 1T4-9 | - | - | - | 0.004 | 0.006 | 0.004 | 0.001 | 0.009[c] |
| 1T4-10 | - | - | - | - | 0.051 | 0.041 | 0.039 | 0.081[c] |
| 1T4-11 | - | - | - | - | 0.023 | 0.013 | 0.004 | 0.035[c] |
| 1T4-12 | - | - | - | - | 0.013 | 0.010 | 0.002 | 0.019[c] |
| 1T4-13 | - | - | - | - | 0.009 | 0.007 | 0.001 | 0.013[c] |
| 1T4-14 | - | - | - | - | 0.007 | 0.007 | 0.001 | 0.009[c] |

a = antennas not constructed.
b = antennas off, grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 A current.

\- = measurement point not established.
-- = measurement point dropped.
/ = measurement not taken.
\# = measurement precluded by antenna operation.

TABLE A-5. 60 Hz MAGNETIC FLUX DENSITIES (mG)
Small Mammals and Nesting Birds Studies
(page 4 of 4)

| Site No., Meas. Pt. | 1983[a] | 1984[a] | 1985[a] | 1986[b] | 1987[c] | 1988[c] | 1989[d] | 1990 |
|---|---|---|---|---|---|---|---|---|
| 1D2-1 | - | - | - | 0.004 | 0.006 | 0.005 | 0.005 | 0.005[d] |
| 1T5-1 | - | 0.001,0.002 | 0.001 | 0.051 | 0.071 | 0.159 | # | 0.156[c] |
| 1T5-7 | - | - | - | - | 0.039 | 0.077 | # | 0.087[c] |
| 1T5-8 | - | - | - | - | 0.016 | 0.025 | # | 0.035[c] |
| 1T5-4 | - | - | - | 0.006 | 0.008 | 0.016 | # | 0.020[c] |
| 1T5-2 | 0.001 | 0.002 | 0.001 | 0.038 | 0.042 | 0.075 | # | 0.020[b] |
| 1T5-9 | - | - | - | - | 0.019 | 0.028 | # | 0.010[b] |
| 1T5-10 | - | - | - | - | 0.011 | 0.017 | # | 0.005[b] |
| 1T5-6 | - | - | - | 0.004 | 0.008 | 0.012 | # | 0.004[b] |
| 1T5-3 | - | - | - | 0.007 | -- | -- | -- | -- |
| 1T5-5 | - | - | - | 0.005 | 0.019 | 0.018 | # | 0.004[b] |
| 1T6-2 | - | - | - | - | 0.111 | 0.34 | # | 0.087,0.177[b,c] |
| 1T6-1 | 0.002 | 0.001 | 0.001 | 0.020 | 0.058 | 0.134 | # | 0.033,0.070[b,c] |
| 1T6-3 | - | - | - | - | 0.020 | 0.061 | # | 0.014,0.031[b,c] |
| 1T6-4 | - | - | - | - | 0.014 | 0.044 | # | 0.011,0.021[b,c] |
| 1T6-5 | - | - | - | - | 0.011 | 0.033 | # | 0.008,0.013[b,c] |
| 1T6-6 | - | - | - | - | 0.008 | 0.023 | # | 0.005[b] |
| 1T6-7 | - | - | - | - | 0.008 | 0.022 | # | 0.004[b] |

a = antennas not constructed.
b = antennas off, grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 A current.

- = measurement point not established.
-- = measurement point dropped.
/ = measurement not taken.
# = measurement precluded by antenna operation.

**TABLE A-6. 76 Hz AIR ELECTRIC FIELD INTENSITIES (V/m)**
**Small Mammals and Nesting Birds Studies**
**(page 1 of 3)**

| SITE NO., MEAS.PT. | 1986 NS 4 amps | 1986 NEW 6 amps | 1986 SEW 6 amps | 1986 SEW 10 amps (EX) | 1987 NS 15 amps | 1987 EW 15 amps | 1988 NS 75 amps | 1988 EW 75 amps | 1989 B 150 amps | 1990 B 150 amps |
|---|---|---|---|---|---|---|---|---|---|---|
| 1C1-3 | < | < | < | * | < | < | < | < | < | < |
| 1C1-4 | < | < | < | * | < | < | < | < | < | < |
| 1C3-1 | < | < | < | * | < | < | < | < | < | < |
| 1C3-3 | < | < | < | * | < | < | < | < | < | < |
| 1C4-1 | < | < | < | * | < | < | < | < | < | < |
| 1C4-4 | < | < | < | * | < | < | < | < | < | < |
| 1C4-5 | - | - | - | - | < | < | < | < | < | < |
| 1D3-1 | < | < | < | * | < | < | < | < | < | < |
| 1C6-1 | < | < | < | * | < | < | < | < | < | < |
| 1C6-3 | < | < | < | * | < | < | < | < | < | < |
| 1C6-4 | < | < | < | * | < | < | < | < | < | < |
| 1L4-1 | - | - | - | - | - | - | < | < | < | < |
| 1T1-14 | < | < | < | * | 0.004 | < | 0.017 | < | 0.036 | 0.036 |
| 1T1-15 | < | < | < | * | 0.001 | < | 0.007 | < | 0.015 | 0.021 |
| 1T1-16 | < | < | < | * | 0.004 | < | 0.012 | < | 0.043 | 0.037 |

NS = north-south antenna.
EW = east-west antenna.
NEW = northern EW antenna element.
SEW = southern EW antenna element.
B = NS + EW antennas, standard phasing.
EX = extrapolated data.

\- = measurement point not established.
< = measurement est. <0.001 V/m based on earth E-field.
* = data cannot be extrapolated.

TABLE A-6. 76 Hz AIR ELECTRIC FIELD INTENSITIES (V/m)
Small Mammals and Nesting Birds Studies
(page 2 of 3)

| SITE NO., MEAS.PT. | 1986 NS 4 amps | 1986 NEW 6 amps | 1986 SEW 6 amps | 1986 SEW 10 amps (EX) | 1987 NS 15 amps | 1987 EW 15 amps | 1988 NS 75 amps | 1988 EW 75 amps | 1989 B 150 amps | 1990 B 150 amps |
|---|---|---|---|---|---|---|---|---|---|---|
| 1T1-17 | 0.002 | < | < | * | 0.004 | < | 0.023 | < | 0.043 | 0.057 |
| 1T1-18 | 0.001 | < | < | * | 0.004 | < | 0.023 | < | 0.052 | 0.055 |
| 1T1-19 | 0.002 | < | < | * | 0.005 | < | 0.032 | < | 0.055 | 0.059 |
| 1T1-20 | 0.002 | < | < | * | 0.004 | < | 0.025 | < | 0.057 | 0.058 |
| 1T1-28 | - | - | - | - | - | - | 0.016 | < | 0.043 | 0.044 |
| 1T1-29 | - | - | - | - | - | - | 0.013 | < | 0.032 | 0.036 |
| 1T1-30 | - | - | - | - | - | - | 0.017 | < | 0.037 | 0.042 |
| 1T1-31 | - | - | - | - | - | - | 0.016 | < | 0.035 | 0.035 |
| 1T1-21 | 1.08 | < | < | * | 3.6 | 0.005 | 15.7 | 0.054 | 32 | 35 |
| 1T1-22 | 0.002 | < | < | * | 0.005 | <0.001 | 0.024 | < | 0.049 | 0.049 |
| 1T1-23 | < | < | < | * | 0.008 | < | 0.033 | < | 0.053 | 0.073 |
| 1T1-24 | < | < | < | * | 0.013 | < | 0.045 | < | 0.150 | 0.091 |
| 1T1-25 | < | < | < | * | 0.019 | < | 0.059 | < | 0.160 | 0.135 |
| 1T1-26 | < | < | < | * | 0.012 | < | 0.044 | < | 0.092 | 0.102 |
| 1T1-27 | < | < | < | * | 0.008 | < | 0.032 | < | 0.060 | 0.068 |
| 1T2-5 | - | - | - | - | 1.28 | 0.014 | 7.3 | 0.100 | 11.1 | 12.2 |
| 1T2-6 | - | - | - | - | 0.169 | 0.002 | 0.84 | 0.013 | 1.17 | 1.33 |
| 1T2-7 | - | - | - | - | 0.034 | <0.001 | 0.29 | 0.004 | 0.25 | 0.34 |
| 1T2-8 | - | - | - | - | 0.014 | < | 0.084 | 0.004 | 0.104 | 0.142 |
| 1T2-9 | - | - | - | - | 0.008 | < | 0.035 | 0.004 | 0.077 | 0.082 |
| 1D1-1 | < | < | < | * | < | < | < | < | 0.007 | 0.010 |
| 1T4-5 | 0.58 | < | < | * | 2.1 | 0.003 | 8.7 | 0.044 | 17.6 | 18.4 |
| 1T4-6 | 0.091 | < | < | * | 0.31 | <0.001 | 1.76 | 0.009 | 4.2 | 4.6 |
| 1T4-7 | 0.022 | < | < | * | 0.089 | < | 0.35 | 0.003 | 0.69 | 0.86 |
| 1T4-8 | 0.005 | < | < | * | 0.014 | < | 0.054 | 0.002 | 0.093 | 0.091 |
| 1T4-9 | 0.002 | < | < | * | 0.008 | < | 0.045 | 0.002 | 0.081 | 0.081 |

NS = north-south antenna.
EW = east-west antenna.
NEW = northern EW antenna element.
SEW = southern EW antenna element.
B = NS + EW antennas, standard phasing.
EX = extrapolated data.

- = measurement point not established.
< = measurement est. <0.001 V/m based on earth E-field.
* = data cannot be extrapolated.

**TABLE A-6. 76 Hz AIR ELECTRIC FIELD INTENSITIES (V/m)**
**Small Mammals and Nesting Birds Studies**
**(page 3 of 3)**

| SITE NO., MEAS.PT. | 1986 NS 4 amps | 1986 NEW 6 amps | 1986 SEW 6 amps | 1986 SEW 10 amps (EX) | 1987 NS 15 amps | 1987 EW 15 amps | 1988 NS 75 amps | 1988 EW 75 amps | 1989 B 150 amps | 1990 B 150 amps |
|---|---|---|---|---|---|---|---|---|---|---|
| 1T4-10 | - | - | - | - | 1.30 | 0.001 | 6.4 | 0.033 | 12.3 | 15.1 |
| 1T4-11 | - | - | - | - | 0.30 | <0.001 | 1.48 | 0.008 | 2.4 | 3.1 |
| 1T4-12 | - | - | - | - | 0.090 | <0.001 | 0.39 | 0.003 | 0.69 | 1.02 |
| 1T4-13 | - | - | - | - | 0.033 | <0.001 | 0.115 | 0.002 | 0.33 | 0.36 |
| 1T4-14 | - | - | - | - | 0.015 | <0.001 | 0.066 | 0.002 | 0.128 | 0.120 |
| 1D2-1 | < | < | < | * | < | 0.003 | 0.001 | 0.001 | 0.011 | 0.013 |
| 1T5-1 | 0.81 | < | < | * | 3.1 | 0.005 | 12.4 | 0.040 | 26 | 41 |
| 1T5-7 | - | - | - | - | 0.54 | 0.001 | 1.78 | 0.005 | 5.2 | 7.6 |
| 1T5-8 | - | - | - | - | 0.008 | <0.001 | 0.039 | < | 0.079 | 0.113 |
| 1T5-4 | 0.002 | < | < | * | 0.007 | < | 0.039 | < | 0.066 | 0.089 |
| 1T5-2 | 0.59 | < | < | * | 2.9 | 0.003 | 15.8 | 0.056 | 23 | 42 |
| 1T5-9 | - | - | - | - | 0.44 | <0.001 | 1.95 | 0.007 | 3.4 | 6.3 |
| 1T5-10 | - | - | - | - | 0.076 | < | 0.29 | 0.001 | 0.63 | 1.06 |
| 1T5-6 | 0.009 | < | < | * | 0.022 | < | 0.135 | < | 0.23 | 0.46 |
| 1T5-5 | 0.005 | < | < | * | 0.019 | < | 0.095 | 0.001 | 0.178 | 0.40 |
| 1T6-2 | - | - | - | - | 3.2 | 0.005 | 14.3 | 0.054 | 31 | 42 |
| 1T6-1 | 0.182 | < | < | * | 0.48 | < | 2.4 | 0.010 | 4.9 | 6.2 |
| 1T6-3 | - | - | - | - | 0.042 | <0.001 | 0.121 | <0.001 | 0.35 | 0.54 |
| 1T6-4 | - | - | - | - | 0.029 | <0.001 | 0.122 | <0.001 | 0.23 | 0.24 |
| 1T6-5 | - | - | - | - | 0.021 | <0.001 | 0.107 | <0.001 | 0.153 | 0.164 |
| 1T6-6 | - | - | - | - | 0.019 | <0.001 | 0.075 | <0.001 | 0.151 | 0.185 |
| 1T6-7 | - | - | - | - | 0.015 | <0.001 | 0.079 | 0.001 | 0.142 | 0.159 |

NS = north-south antenna.
EW = east-west antenna.
NEW = northern EW antenna element.
SEW = southern EW antenna element.
B = NS + EW antennas, standard phasing.
EX = extrapolated data.

- = measurement point not established.
< = measurement est. <0.001 V/m based on earth E-field.
* = data cannot be extrapolated.

TABLE A-7. 76 Hz EARTH ELECTRIC FIELD INTENSITIES (mV/m)
Small Mammals and Nesting Birds Studies
(page 1 of 3)

| SITE NO., MEAS.PT. | 1986 NS 4 amps | 1986 NEW 6 amps | 1986 SEW 6 amps | 1986 SEW 10 amps (EX) | 1987 NS 15 amps | 1987 EW 15 amps | 1988 NS 75 amps | 1988 EW 75 amps | 1989 B 150 amps | 1990 B 150 amps |
|---|---|---|---|---|---|---|---|---|---|---|
| 1C1-3 | 0.021 | 0.003 | 0.010 | 0.017 | 0.082 | 0.028 | 0.44 | 0.139 | 1.31 | 1.04 |
| 1C1-4 | / | / | / | / | 0.087 | 0.033 | 0.42 | 0.185 | 1.70 | 1.33 |
| 1C3-1 | / | / | / | / | 0.050 | 0.025 | 0.26 | 0.119 | 0.74 | 0.81 |
| 1C3-3 | 0.022 | 0.004 | 0.012 | 0.020 | 0.086 | 0.032 | 0.41 | 0.157 | 1.18 | 0.98 |
| 1C4-1 | / | / | / | / | 0.005 | 0.004 | 0.023 | 0.019 | 0.070 | 0.073 |
| 1C4-4 | <0.001 | <0.001 | <0.001 | * | 0.002 | 0.002 | 0.005 | 0.005 | 0.030 | 0.023 |
| 1C4-5 | - | - | - | - | 0.003 | 0.002 | 0.012 | 0.008 | 0.037 | 0.035 |
| 1D3-1 | 0.008 | 0.004 | 0.005 | 0.008 | 0.053 | 0.019 | 0.21 | 0.065 | 0.85 | 0.89 |
| 1C6-1 | / | / | / | / | 0.004 | 0.003 | 0.017 | 0.017 | 0.083 | 0.100 |
| 1C6-3 | 0.001 | <0.001 | 0.001 | 0.002 | 0.008 | 0.004 | 0.026 | 0.016 | 0.110 | 0.078 |
| 1C6-4 | / | / | / | / | 0.003 | 0.002 | 0.017 | 0.009 | 0.045 | 0.043 |
| 1L4-1 | - | - | - | - | - | - | 0.006 | 0.002 | 0.013 | 0.020 |
| 1T1-14 | 0.86 | 0.026 | 0.021 | 0.035 | 3.1 | 0.069 | 18.1 | 0.21 | 34 | 40 |
| 1T1-15 | 0.43 | 0.013 | 0.015 | 0.025 | 1.60 | 0.051 | 9.2 | 0.21 | 13.6 | 14.1 |
| 1T1-16 | 1.11 | 0.035 | 0.035 | 0.058 | 4.6 | 0.133 | 24 | 0.61 | 47 | 50 |

NS = north-south antenna.
EW = east-west antenna.
NEW = northern EW antenna element.
SEW = southern EW antenna element.
B = NS + EW antennas, standard phasing.
EX = extrapolated data.

- = measurement point not established.
/ = measurement not taken.
* = data cannot be extrapolated.

TABLE A-7. 76 Hz EARTH ELECTRIC FIELD INTENSITIES (mV/m)
Small Mammals and Nesting Birds Studies
(page 2 of 3)

| SITE NO., MEAS.PT. | 1986 NS 4 amps | 1986 NEW 6 amps | 1986 SEW 6 amps | 1986 SEW 10 amps (EX) | 1987 NS 15 amps | 1987 EW 15 amps | 1988 NS 75 amps | 1988 EW 75 amps | 1989 B 150 amps | 1990 B 150 amps |
|---|---|---|---|---|---|---|---|---|---|---|
| 1T1-17 | 1.55 | 0.049 | 0.053 | 0.088 | 6.2 | 0.139 | 23 | 0.57 | 43 | 39 |
| 1T1-18 | 1.44 | 0.042 | 0.050 | 0.083 | 5.6 | 0.166 | 26 | 0.71 | 49 | 55 |
| 1T1-19 | 1.54 | 0.050 | 0.053 | 0.088 | 6.4 | 0.142 | 28 | 0.69 | 57 | 58 |
| 1T1-20 | 1.45 | 0.046 | 0.043 | 0.072 | 6.0 | 0.142 | 28 | 0.77 | 56 | 56 |
| 1T1-28 | - | - | - | - | - | - | 25 | 0.74 | 54 | 58 |
| 1T1-29 | - | - | - | - | - | - | 16.1 | 0.58 | 35 | 37 |
| 1T1-30 | - | - | - | - | - | - | 17.2 | 0.63 | 39 | 41 |
| 1T1-31 | - | - | - | - | - | - | 20 | 0.71 | 41 | 40 |
| 1T1-21 | 1.45 | 0.044 | 0.009 | 0.015 | 7.4 | 0.026 | 31 | 0.133 | 54 | 49 |
| 1T1-22 | 1.50 | 0.042 | 0.009 | 0.015 | 4.2 | 0.021 | 25 | 0.62 | 41 | 42 |
| 1T1-23 | 0.96 | 0.030 | 0.003 | 0.005 | 2.9 | 0.017 | 18.7 | 0.109 | 33 | 30 |
| 1T1-24 | 1.15 | 0.036 | 0.010 | 0.017 | 4.7 | 0.020 | 14.8 | 0.117 | 59 | 35 |
| 1T1-25 | 0.87 | 0.027 | 0.062 | 0.103 | 2.9 | 0.019 | 15.6 | 0.079 | 33 | 29 |
| 1T1-26 | 0.56 | 0.017 | 0.004 | 0.007 | 2.0 | 0.014 | 12.3 | 0.082 | 23 | 23 |
| 1T1-27 | 0.38 | 0.012 | 0.004 | 0.007 | 1.82 | 0.015 | 6.2 | 0.057 | 19.3 | 13.7 |
| 1T2-5 | - | - | - | - | 8.7 | 0.77 | 39 | 3.1 | 85 | 88 |
| 1T2-6 | - | - | - | - | 8.5 | 0.86 | 41 | 4.6 | 86 | 82 |
| 1T2-7 | - | - | - | - | 7.0 | 0.56 | 31 | 2.7 | 70 | 66 |
| 1T2-8 | - | - | - | - | 7.1 | 0.66 | 31 | 3.6 | 70 | 67 |
| 1T2-9 | - | - | - | - | 6.2 | 0.79 | 31 | 3.6 | 70 | 65 |
| 1D1-1 | 0.042 | 0.28 | 0.066 | 0.110 | 0.23 | 0.67 | 1.15 | 3.4 | 7.6 | 6.1 |
| 1T4-5 | 2.1 | 0.062 | 0.054 | 0.090 | 6.4 | 0.191 | 34 | 0.76 | 84 | 68 |
| 1T4-6 | 2.5 | 0.076 | 0.103 | 0.172 | 6.3 | 0.29 | 45 | 1.35 | 87 | 64 |
| 1T4-7 | 2.2 | 0.067 | 0.092 | 0.153 | 8.7 | 0.30 | 37 | 1.40 | 76 | 50 |
| 1T4-8 | 1.91 | 0.061 | 0.123 | 0.21 | 7.7 | 0.31 | 32 | 1.59 | 72 | 70 |
| 1T4-9 | 2.1 | 0.062 | 0.126 | 0.21 | 6.2 | 0.34 | 35 | 1.74 | 55 | 82 |

NS = north-south antenna.
EW = east-west antenna.
NEW = northern EW antenna element.
SEW = southern EW antenna element.
B = NS + EW antennas, standard phasing.
EX = extrapolated data.

- = measurement point not established.
/ = measurement not taken.
* = data cannot be extrapolated.

TABLE A-7. 76 Hz EARTH ELECTRIC FIELD INTENSITIES (mV/m)
Small Mammals and Nesting Birds Studies
(page 3 of 3)

| SITE NO., MEAS.PT. | 1986 NS 4 amps | 1986 NEW 6 amps | 1986 SEW 6 amps | 1986 SEW 10 amps (EX) | 1987 NS 15 amps | 1987 EW 15 amps | 1988 NS 75 amps | 1988 EW 75 amps | 1989 B 150 amps | 1990 B 150 amps |
|---|---|---|---|---|---|---|---|---|---|---|
| 1T4-10 | - | - | - | - | 12.4 | 0.29 | 47 | 1.30 | 86 | 97 |
| 1T4-11 | - | - | - | - | 6.4 | 0.27 | 34 | 1.26 | 83 | 79 |
| 1T4-12 | - | - | - | - | 7.4 | 0.38 | 39 | 1.31 | 76 | 75 |
| 1T4-13 | - | - | - | - | 5.7 | 0.33 | 29 | 1.60 | 70 | 66 |
| 1T4-14 | - | - | - | - | 6.7 | 0.33 | 31 | 1.56 | 55 | 72 |
| 1D2-1 | 0.094 | 0.44 | 0.113 | 0.188 | 0.41 | 1.36 | 1.58 | 4.8 | 9.7 | 10.2 |
| 1T5-1 | 2.6 | 0.079 | 0.074 | 0.123 | 9.7 | 0.21 | 47 | 0.94 | 110 | 85 |
| 1T5-7 | - | - | - | - | 8.4 | 0.21 | 48 | 1.01 | 78 | 84 |
| 1T5-8 | - | - | - | - | 8.2 | 0.20 | 38 | 0.87 | 90 | 92 |
| 1T5-4 | 1.39 | 0.042 | 0.061 | 0.102 | 5.8 | 0.21 | 29 | 0.98 | 61 | 69 |
| 1T5-2 | 1.97 | 0.064 | 0.108 | 0.180 | 8.2 | 0.23 | 24 | 0.77 | 70 | 54 |
| 1T5-9 | - | - | - | - | 7.2 | 0.29 | 19.5 | 0.84 | 47 | 54 |
| 1T5-10 | - | - | - | - | 3.4 | 0.170 | 14.4 | 1.00 | 36 | 32 |
| 1T5-6 | 1.08 | 0.037 | 0.070 | 0.117 | 3.3 | 0.21 | 13.1 | 0.98 | 32 | 38 |
| 1T5-5 | 1.31 | 0.051 | 0.101 | 0.168 | 5.2 | 0.33 | 23 | 1.40 | 45 | 53 |
| 1T6-2 | - | - | - | - | 27. | 0.24 | 71 | 0.79 | 250 | 270 |
| 1T6-1 | 5.4 | 0.159 | 0.086 | 0.143 | 32. | 0.25 | 102 | 1.03 | 169 | 122 |
| 1T6-3 | - | - | - | - | 21. | 0.144 | 97 | 0.67 | 187 | 240 |
| 1T6-4 | - | - | - | - | 16.3 | 0.122 | 87 | 0.61 | 139 | 236 |
| 1T6-5 | - | - | - | - | 15.3 | 0.22 | 80 | 1.27 | 143 | 124 |
| 1T6-6 | - | - | - | - | 11.6 | 0.132 | 63 | 0.66 | 128 | 103 |
| 1T6-7 | - | - | - | - | 6.0 | 0.178 | 87 | 1.41 | 120 | 177 |

NS = north-south antenna.
EW = east-west antenna.
NEW = northern EW antenna element.
SEW = southern EW antenna element.
B = NS + EW antennas, standard phasing.
EX = extrapolated data.

\- = measurement point not established.
/ = measurement not taken.
* = data cannot be extrapolated.

TABLE A-8. 76 Hz MAGNETIC FLUX DENSITIES (mG)
Small Mammals and Nesting Birds Studies
(page 1 of 3)

| SITE NO., MEAS.PT. | 1986 NS 4 amps | 1986 NEW 6 amps | 1986 SEW 6 amps | 1986 SEW 10 amps (EX) | 1987 NS 15 amps | 1987 EW 15 amps | 1988 NS 75 amps | 1988 EW 75 amps | 1989 B 150 amps | 1990 B 150 amps |
|---|---|---|---|---|---|---|---|---|---|---|
| 1C1-3 | <0.001 | <0.001 | <0.001 | * | 0.001 | <0.001 | 0.003 | 0.001 | 0.007 | 0.007 |
| 1C1-4 | / | / | / | / | 0.001 | <0.001 | 0.003 | 0.001 | 0.006 | 0.006 |
| 1C3-1 | / | / | / | / | 0.001 | <0.001 | 0.003 | 0.001 | 0.008 | 0.007 |
| 1C3-3 | <0.001 | <0.001 | <0.001 | * | 0.001 | <0.001 | 0.003 | 0.001 | 0.007 | 0.008 |
| 1C4-1 | / | / | / | / | <0.001 | <0.001 | 0.001 | <0.001 | 0.001 | 0.002 |
| 1C4-4 | <0.001 | <0.001 | <0.001 | * | <0.001 | <0.001 | 0.001 | <0.001 | 0.002 | 0.002 |
| 1C4-5 | - | - | - | - | <0.001 | <0.001 | 0.001 | <0.001 | 0.002 | 0.002 |
| 1D3-1 | <0.001 | <0.001 | <0.001 | * | <0.001 | <0.001 | 0.002 | 0.002 | 0.008 | 0.008 |
| 1C6-1 | / | / | / | / | <0.001 | <0.001 | 0.001 | 0.001 | 0.004 | 0.003 |
| 1C6-3 | <0.001 | <0.001 | <0.001 | * | <0.001 | <0.001 | 0.001 | 0.001 | 0.004 | 0.004 |
| 1C6-4 | / | / | / | / | <0.001 | <0.001 | 0.002 | 0.001 | 0.005 | 0.005 |
| 1L4-1 | - | - | - | - | - | - | <0.001 | <0.001 | 0.002 | 0.002 |
| 1T1-14 | 0.032 | 0.001 | 0.001 | 0.002 | 0.115 | 0.003 | 0.65 | 0.014 | 1.35 | 1.29 |
| 1T1-15 | 0.027 | 0.001 | 0.001 | 0.002 | 0.097 | 0.003 | 0.47 | 0.012 | 1.01 | 0.98 |
| 1T1-16 | 0.069 | 0.002 | 0.001 | 0.002 | 0.22 | 0.002 | 1.05 | 0.013 | 2.1 | 2.1 |

NS = north-south antenna.
EW = east-west antenna.
NEW = northern EW antenna element.
SEW = southern EW antenna element.
B = NS + EW antennas, standard phasing.
EX = extrapolated data.

\- = measurement point not established.
/ = measurement not taken.
* = data cannot be extrapolated.

TABLE A-8. 76 Hz MAGNETIC FLUX DENSITIES (mG)
Small Mammals and Nesting Birds Studies
(page 2 of 3)

| SITE NO., MEAS.PT. | 1986 NS 4 amps | 1986 NEW 6 amps | 1986 SEW 6 amps | 1986 SEW 10 amps (EX) | 1987 NS 15 amps | 1987 EW 15 amps | 1988 NS 75 amps | 1988 EW 75 amps | 1989 B 150 amps | 1990 B 150 amps |
|---|---|---|---|---|---|---|---|---|---|---|
| 1T1-17 | 0.076 | 0.003 | 0.001 | 0.002 | 0.23 | 0.001 | 1.49 | 0.012 | 2.9 | 2.9 |
| 1T1-18 | 0.071 | 0.002 | 0.001 | 0.002 | 0.27 | 0.002 | 1.28 | 0.012 | 2.6 | 2.6 |
| 1T1-19 | 0.081 | 0.003 | 0.001 | 0.002 | 0.32 | 0.002 | 1.51 | 0.013 | 3.1 | 3.1 |
| 1T1-20 | 0.089 | 0.003 | 0.001 | 0.002 | 0.36 | 0.002 | 1.68 | 0.013 | 3.3 | 3.4 |
| 1T1-28 | - | - | - | - | - | - | 1.25 | 0.015 | 2.4 | 2.4 |
| 1T1-29 | - | - | - | - | - | - | 1.10 | 0.015 | 2.1 | 2.2 |
| 1T1-30 | - | - | - | - | - | - | 1.12 | 0.015 | 2.3 | 2.3 |
| 1T1-31 | - | - | - | - | - | - | 1.00 | 0.015 | 2.1 | 2.1 |
| 1T1-21 | 0.78 | 0.024 | 0.004 | 0.007 | 2.9 | 0.005 | 13.8 | 0.043 | 32 | 29 |
| 1T1-22 | 0.31 | 0.010 | 0.002 | 0.003 | 1.16 | 0.016 | 5.8 | 0.019 | 12.3 | 11.6 |
| 1T1-23 | 0.169 | 0.005 | 0.001 | 0.002 | 0.64 | 0.003 | 3.0 | 0.013 | 6.6 | 6.0 |
| 1T1-24 | 0.113 | 0.004 | 0.001 | 0.002 | 0.43 | 0.003 | 2.1 | 0.011 | 4.3 | 4.2 |
| 1T1-25 | 0.084 | 0.003 | 0.007 | 0.012 | 0.32 | 0.003 | 1.52 | 0.011 | 3.4 | 3.2 |
| 1T1-26 | 0.055 | 0.002 | 0.001 | 0.002 | 0.21 | 0.002 | 1.00 | 0.010 | 2.2 | 1.92 |
| 1T1-27 | 0.040 | 0.012 | 0.001 | 0.002 | 0.149 | 0.002 | 0.69 | 0.009 | 1.51 | 1.39 |
| 1T2-5 | - | - | - | - | 3.2 | 0.005 | 15.1 | 0.053 | 33 | 30 |
| 1T2-6 | - | - | - | - | 1.23 | 0.003 | 5.8 | 0.031 | 12.0 | 11.1 |
| 1T2-7 | - | - | - | - | 0.64 | 0.002 | 3.1 | 0.023 | 6.4 | 6.2 |
| 1T2-8 | - | - | - | - | 0.43 | 0.003 | 2.1 | 0.020 | 4.3 | 4.0 |
| 1T2-9 | - | - | - | - | 0.32 | 0.003 | 1.59 | 0.019 | 3.3 | 3.0 |
| 1D1-1 | <0.001 | 0.003 | 0.001 | 0.002 | 0.001 | 0.011 | 0.004 | 0.053 | 0.102 | 0.131 |
| 1T4-5 | 0.70 | 0.022 | 0.004 | 0.007 | 2.9 | 0.004 | 13.4 | 0.047 | 29 | 28 |
| 1T4-6 | 0.32 | 0.010 | 0.002 | 0.003 | 1.21 | 0.002 | 5.7 | 0.025 | 12.6 | 11.6 |
| 1T4-7 | 0.171 | 0.005 | 0.001 | 0.002 | 0.66 | 0.001 | 3.1 | 0.017 | 6.4 | 6.0 |
| 1T4-8 | 0.116 | 0.003 | 0.001 | 0.002 | 0.43 | 0.002 | 2.1 | 0.014 | 4.3 | 4.1 |
| 1T4-9 | 0.085 | 0.003 | 0.001 | 0.002 | 0.34 | 0.002 | 1.55 | 0.012 | 3.2 | 3.0 |

NS = north-south antenna.
EW = east-west antenna.
NEW = northern EW antenna element.
SEW = southern EW antenna element.
B = NS + EW antennas, standard phasing.
EX = extrapolated data.

- = measurement point not established.
/ = measurement not taken.
* = data cannot be extrapolated.

TABLE A-8. 76 Hz MAGNETIC FLUX DENSITIES (mG)
Small Mammals and Nesting Birds Studies
(page 3 of 3)

| SITE NO., MEAS.PT. | 1986 NS 4 amps | 1986 NEW 6 amps | 1986 SEW 6 amps | 1986 SEW 10 amps (EX) | 1987 NS 15 amps | 1987 EW 15 amps | 1988 NS 75 amps | 1988 EW 75 amps | 1989 B 150 amps | 1990 B 150 amps |
|---|---|---|---|---|---|---|---|---|---|---|
| 1T4-10 | - | - | - | - | 2.7 | 0.004 | 16.5 | 0.042 | 26 | 25 |
| 1T4-11 | - | - | - | - | 0.87 | 0.003 | 5.3 | 0.015 | 11.7 | 11 |
| 1T4-12 | - | - | - | - | 0.64 | 0.002 | 2.9 | 0.008 | 6.3 | 5.9 |
| 1T4-13 | - | - | - | - | 0.43 | 0.002 | 2.0 | 0.007 | 4.3 | 4.0 |
| 1T4-14 | - | - | - | - | 0.32 | 0.002 | 1.55 | 0.006 | 3.2 | 3.0 |
| 1D2-1 | <0.001 | 0.003 | 0.001 | 0.002 | 0.002 | 0.008 | 0.009 | 0.043 | 0.077 | 0.078 |
| 1T5-1 | 0.89 | 0.029 | 0.005 | 0.008 | 3.6 | 0.005 | 17.0 | 0.059 | 34 | 34 |
| 1T5-7 | - | - | - | - | 1.93 | 0.002 | 8.9 | 0.035 | 18.9 | 17.6 |
| 1T5-8 | - | - | - | - | 0.75 | 0.001 | 3.5 | 0.017 | 7.3 | 7.3 |
| 1T5-4 | 0.124 | 0.004 | 0.001 | 0.002 | 0.46 | 0.001 | 2.2 | 0.013 | 4.5 | 4.4 |
| 1T5-2 | 0.77 | 0.024 | 0.004 | 0.007 | 3.1 | 0.004 | 14.4 | 0.052 | 31 | 29 |
| 1T5-9 | - | - | - | - | 1.18 | 0.003 | 5.6 | 0.017 | 11.7 | 11.2 |
| 1T5-10 | - | - | - | - | 0.67 | 0.002 | 3.2 | 0.009 | 6.1 | 6.1 |
| 1T5-6 | 0.125 | 0.004 | <0.001 | * | 0.46 | 0.002 | 2.1 | 0.007 | 4.5 | 4.5 |
| 1T5-5 | 0.131 | 0.004 | 0.001 | 0.002 | 0.53 | 0.001 | 2.5 | 0.014 | 5.1 | 5.2 |
| 1T6-2 | - | - | - | - | 3.9 | 0.006 | 17.8 | 0.061 | 35 | 37 |
| 1T6-1 | 0.40 | 0.013 | 0.002 | 0.003 | 1.51 | 0.004 | 7.2 | 0.021 | 14.7 | 14.7 |
| 1T6-3 | - | - | - | - | 0.65 | 0.002 | 3.2 | 0.008 | 6.5 | 6.3 |
| 1T6-4 | - | - | - | - | 0.44 | 0.002 | 2.1 | 0.006 | 4.7 | 4.9 |
| 1T6-5 | - | - | - | - | 0.34 | 0.002 | 1.70 | 0.004 | 3.5 | 3.4 |
| 1T6-6 | - | - | - | - | 0.24 | 0.016 | 1.17 | 0.004 | 2.4 | 2.4 |
| 1T6-7 | - | - | - | - | 0.22 | 0.002 | 1.05 | 0.005 | 2.1 | 2.1 |

NS = north-south antenna.
EW = east-west antenna.
NEW = northern EW antenna element.
SEW = southern EW antenna element.
B = NS + EW antennas, standard phasing.
EX = extrapolated data.

\- = measurement point not established.
/ = measurement not taken.
* = data cannot be extrapolated.

**TABLE A-9. 60 Hz AIR ELECTRIC FIELD INTENSITIES (V/m)**
**Small Mammals and Nesting Birds Studies Laboratory**

| Site No., Meas. Pt. | 1986 | 1987 | 1988 | 1989 | 1990 Before Shielding | 1990 After Shielding |
|---|---|---|---|---|---|---|
| 1L1-1 | / | – | – | – | – | – |
| 1L1-2 | 0.94 | 0.96 | – | – | – | – |
| 1L1-3 | 0.79 | 0.034 | / | / | / | 0.58 |
| 1L1-4 | 0.042 | 0.047 | 0.062 | / | / | / |
| 1L1-5 | - | - | - | / | / | / |
| 1L1-6 | - | - | - | / | / | / |
| 1L1-7 | - | - | - | 8.1 | 8.5 | 1.34 |
| 1L1-8 | - | - | - | 0.88 | 0.76 | 0.037 |
| 1L1-9 | - | - | - | 60 | 18.1 | 3.9* |
| 1L1-10 | - | - | - | - | / | 0.010 |

- = measurement point not established.
– = measurement point dropped.
/ = *data not taken.*
* = 4.0 V/m with humidifier on.

**TABLE A-10. 60 Hz MAGNETIC FLUX DENSITIES (mG)**
**Small Mammals and Nesting Birds Studies Laboratory**

| Site No., Meas. Pt. | 1986 | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|---|
| 1L1-1 | 9.13 | – | – | – | – |
| 1L1-2 | 0.179 | 0.156 | – | – | – |
| 1L1-3 | 0.080 | 0.143 | / | / | 0.071 |
| 1L1-4 | 0.114 | 0.118 | 0.080 | 0.075 | / |
| 1L1-5 | - | - | - | 14.1[a] | 5.2[c] |
| | | | | 21[b] | 0.62[d] |
| 1L1-6 | - | - | - | 3.2[a] | 0.077[e] |
| | | | | | 2.4[c] |
| | | | | 44[b] | 0.195[d] |
| | | | | | 0.081[e] |
| 1L1-7 | - | - | - | 0.65 | 1.69 |
| 1L1-8 | - | - | - | 1.46 | 0.88 |
| 1L1-9 | - | - | - | 48 | 0.86 |
| 1L1-10 | - | - | - | - | 0.75 |

a = measurement made in vertical orientation only in an open, unshielded can, submerged to its rim.
b = measurement made above the bath surface.
c = measurement made in closed, unshielded, fully submerged can.
d = measurement made in closed, shielded, fully submerged can.
e = measurement made in closed, shielded, fully submerged can with motor and pump shielding (final configuration; see Figure A-40).
- = measurement point not established.
– = measurement point dropped.
/ = data not taken.

# APPENDIX B

# NATIVE BEES STUDIES

## NATIVE BEES STUDIES

These studies incorporate investigations of the nesting and development traits of bees native to the ELF system area in Michigan. The electric and magnetic fields present in the air are considered the most important factors in the orientation and site tenacity of bees during their nesting cycle. The electric and magnetic fields in the earth and near its surface may be of importance in developmental studies. The air electric field and magnetic field in the laboratory where the bee nesting blocks are examined, and in the holding areas used prior to examination, are also of importance.

IITRI field crews made ELF electromagnetic (EM) field measurements at 21 measurement points for the native bees studies in 1990. The points are dispersed within the two treatment sites, the two control sites, the Crystal Falls laboratory, and the remote holding facility. The treatment and control site measurement points were the same as those used in 1989. At the laboratory measurement points 2L1-1, 2, 4, and 5 were dropped because bees are no longer exposed to these areas. Measurement points 2L1-7, 8, and 9 were added to the second-floor laboratory work area to replace measurement point 2L1-6 and to better characterize this work area. Measurement dates for 1990 and previous years appear in Table B-1.

The positions of the six sites relative to the NRTF-Republic are shown on the composite map in Figure B-1. The site numbers listed on the map are those used by IITRI. Table B-2 provides a cross-reference of IITRI site numbers, investigator site names, and township, range, and section numbers for the sites. Details of measurement locations within sites are given in Figures B-2 through B-8.

**TABLE B-1. EM FIELD MEASUREMENT DATES**
**Native Bees Studies**

| Year | Measurement Dates | | |
|---|---|---|---|
| 1983 | May 25 | Jul 13 | |
| 1984 | May 16 | Aug 13-16, 20, 22 | |
| 1985 | Jul 15, 22, 23 | | |
| 1986 | Oct 6, 8, 13, 16 | | |
| 1987 | Sep 29, 30 | Oct 2 | |
| 1988 | Sep 19-22, 28 | | |
| 1989 | May 10 | Sep 13, 20, 22 | |
| 1990 | May 9 | Sep 24 | Oct 2, 5, 8 |

EM field measurements for 1990 and previous years are found in Tables B-3 through B-8. Tables B-3, B-4, and B-5 present 60 Hz data for the air electric field, earth electric field, and magnetic flux density,

**TABLE B-2. SITE NO. CROSS-REFERENCE**
**Native Bees Studies**

| IITRI Site No. | Investigator's Site Name | Location | | | | |
|---|---|---|---|---|---|---|
| | | Township | : | Range | : | Section(s) |
| 2T1 | Ford 1 (F1) | T43N | : | R29W | : | 14 |
| 2T2 | Ford 2 (F2) | T43N | : | R29W | : | 14 |
| 2C4 | County Line Road (CL) | T43N | : | R30W | : | 19 |
| 2C5 | Camp 5 (C5) | T42N | : | R31W | : | 13 |
| 2L1 | Crystal Falls Laboratory | T43N | : | R32W | : | 29 |
| 2L2 | Remote Holding Facility | T42N | : | R32W | : | 9 |

respectively. Tables B-6, B-7, and B-8 present 76 Hz data for these three fields along with the corresponding operating currents of the NRTF-Republic for each year.

Considerable year-to-year variability in the 60 Hz EM fields is evident. The primary factors in this variability at treatment sites are changes in power line loading conditions (which are unknown) and differences in the configuration of the antennas at the time of measurement. Notes on the antenna configurations are included in the tables primarily for engineering use. The 60 Hz measurements at treatment sites in 1986, 1987, 1988, and 1990 were taken while the antennas were off, and are representative of 60 Hz levels present during maintenance periods. In 1989, the antenna status (modulated signal) precluded 60 Hz EM field measurements at the treatment sites. However, measurements were possible at treatment sites for other studies in 1989 during unmodulated operation of the antennas. These measurements indicate that 60 Hz EM fields present during operation of the antennas are comparable to those present when the antennas are off.

Annual variations in the 60 Hz fields measured at the control study sites are also caused by differences in power line loading, but are not dependent on the antennas or their configuration because of the distance of these sites from the antennas. The 60 Hz field values at the control sites are about as variable as those at the treatment sites.

Overall, the 60 Hz EM fields measured at all study sites in 1990 are consistent with previous field values and with the expected differences in power line loads and antenna configuration. Regardless of the field variability associated with the measurement condition, 76 Hz EM fields at treatment sites consistently dominate the 60 Hz EM fields at treatment and control sites, and the ratios of 60 Hz EM fields between matched treatment/control sites continue to meet exposure criteria guidelines established at the beginning of the study.

The 76 Hz EM field measurements in 1990 were made with 150 ampere antenna currents, the predominant operating current of the NRTF-Republic since 4 May 1989. The antenna currents at which measurements were made in each year are given in the column headings of the Tables B-6 through B-8. The annual increases in field magnitudes reflect the level of antenna current at the time of measurement: 4 or 6 amperes in 1986, 15 amperes in 1987, 75 amperes in 1988, and 150 amperes in 1989 and 1990. The 1990 measurements are consistent with the 1989 measurements at the same current, and proportional to the 1986, 1987, and 1988 measurements made at lower currents.

The 60 Hz EM fields measured at the Crystal Falls laboratory in 1989 were significantly higher (up to 1000 times) than the 60 Hz fields measured at any of the study sites. Some of the laboratory 60 Hz air electric field exposures even exceed the 76 Hz exposures at the treatment sites. These relatively high intensities could mask differences caused by exposures at treatment and control sites. As discussed in Section 4.1.2 of this report, the duration of exposure of nest boxes at the Crystal Falls laboratory has been minimized by using the remote holding facility, set up by the small mammals and nesting birds studies researchers, for temporary nest storage. In addition, IITRI built wire-mesh Faraday cage shields to reduce the 60 Hz air electric field exposures of the bees while at the Crystal Falls laboratory. These cages were installed prior to 1990 laboratory work.

Air electric field shielding at the Crystal Falls laboratory was also discussed in Section 4.1.2 of this report. Table B-9 presents 60 Hz air electric field data before and after shielding was implemented in the Crystal Falls laboratory. It can be seen from this table that the shields provided a nominal factor of 100 reduction in the air electric field exposure at the laboratory work areas.

The 60 Hz magnetic flux densities measured at the Crystal Falls laboratory appear in Table B-10. The 1990 magnetic flux density levels are similar to those measured in 1989. They are typically at least a factor of 10 lower than the 76 Hz magnetic flux densities measured at the treatment sites during full-power antenna operation. Shielding of the magnetic fields is not being considered for this laboratory.

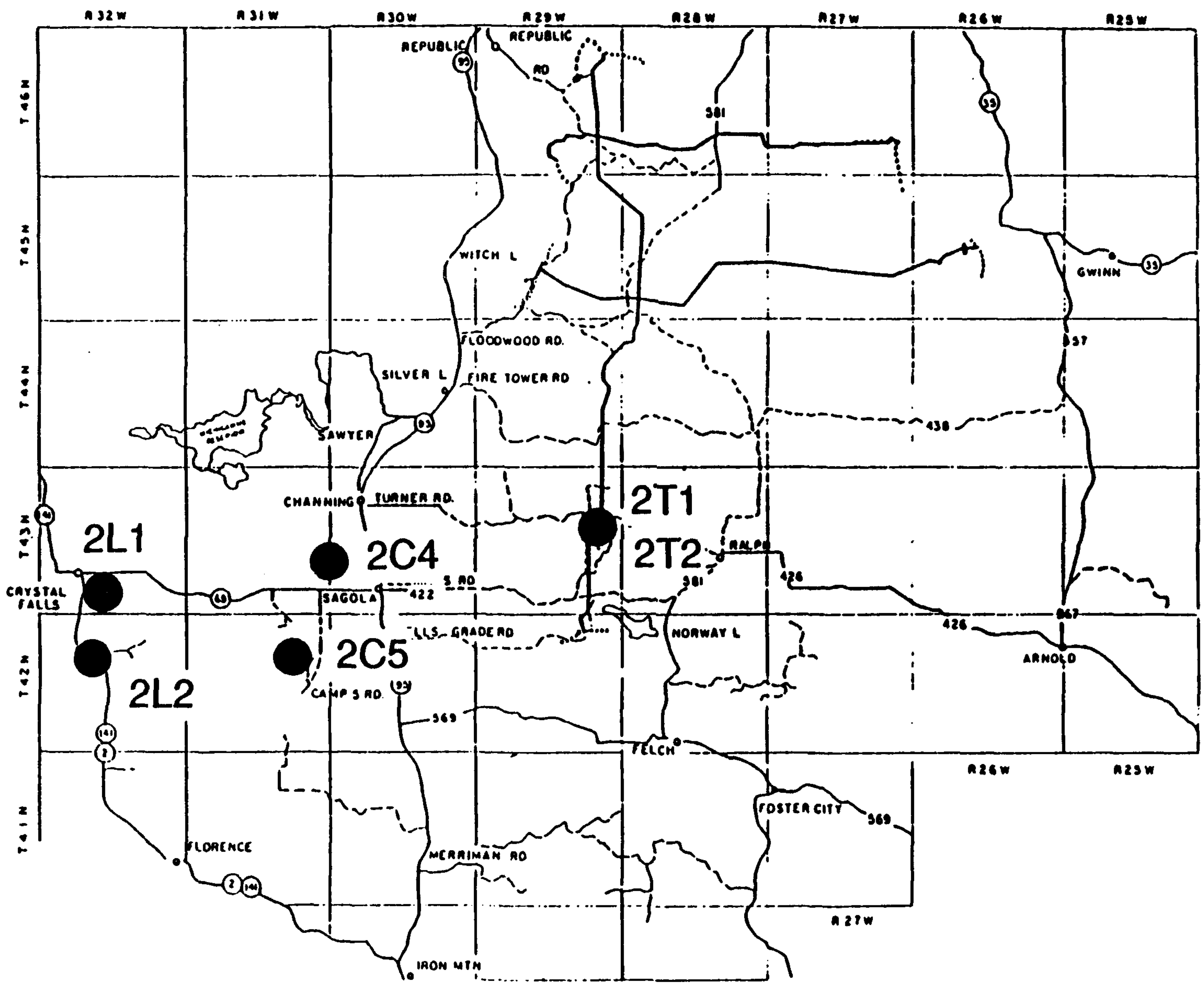



FIGURE B-1. POSITIONS OF NATIVE BEES STUDY SITES RELATIVE TO NRTF-REPUBLIC ANTENNA ELEMENTS.

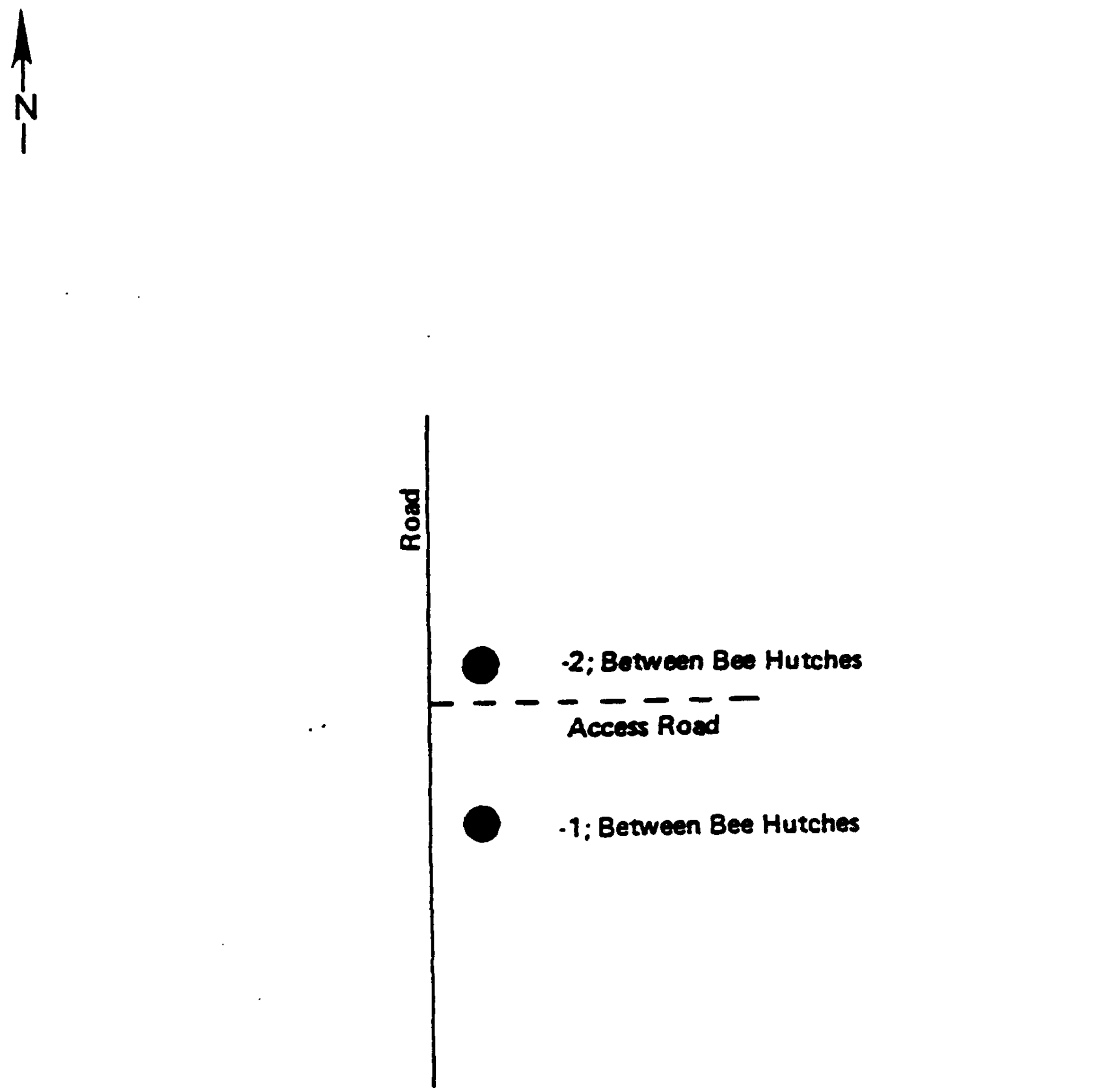



**FIGURE B-2. MEASUREMENT POINTS AT COUNTY LINE ROAD (CL); 2C4-1, 2.**

60297/790

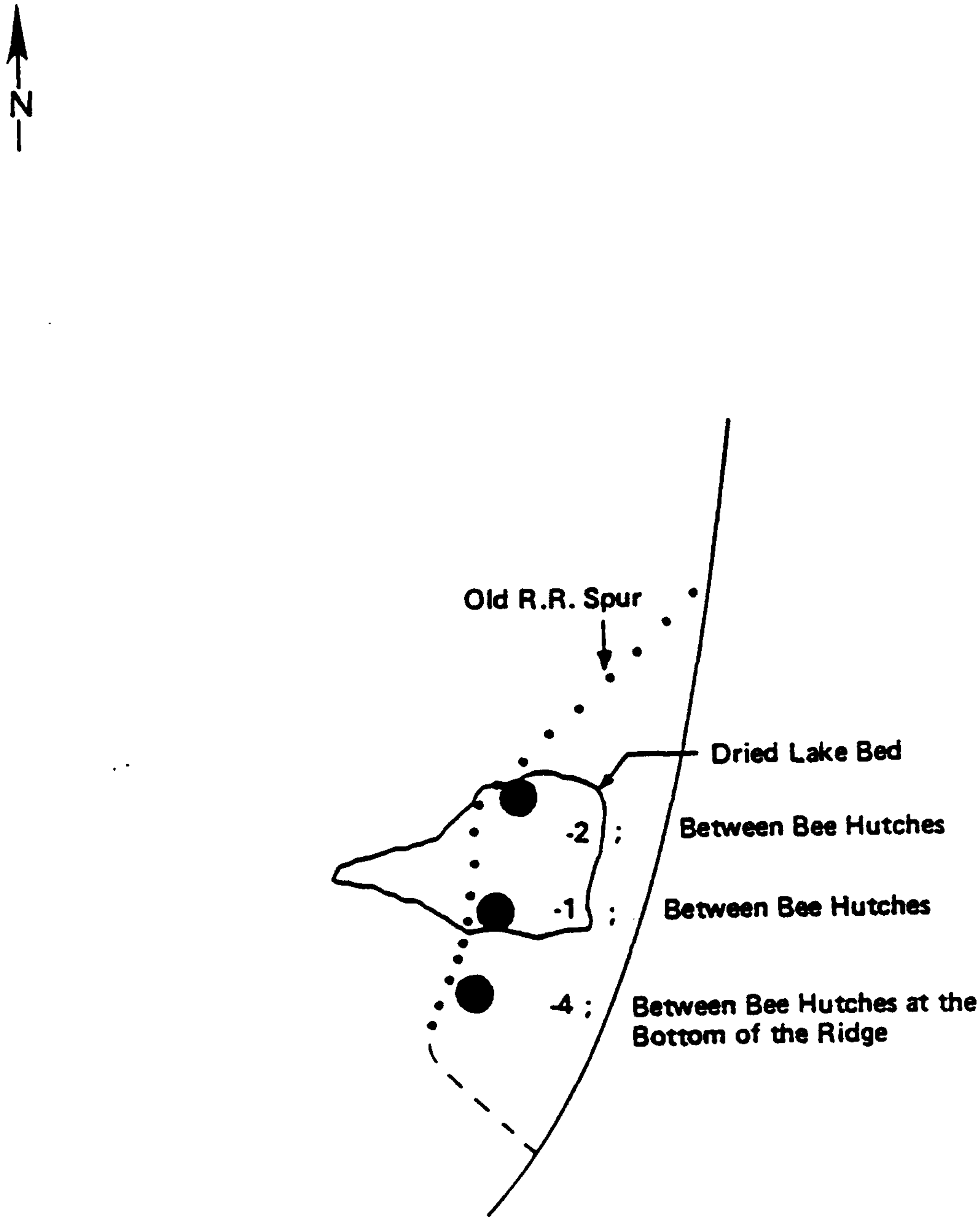



**FIGURE B-3. MEASUREMENT POINTS AT CAMP 5 (C5); 2C5-1, 2, 4.**

60297/790

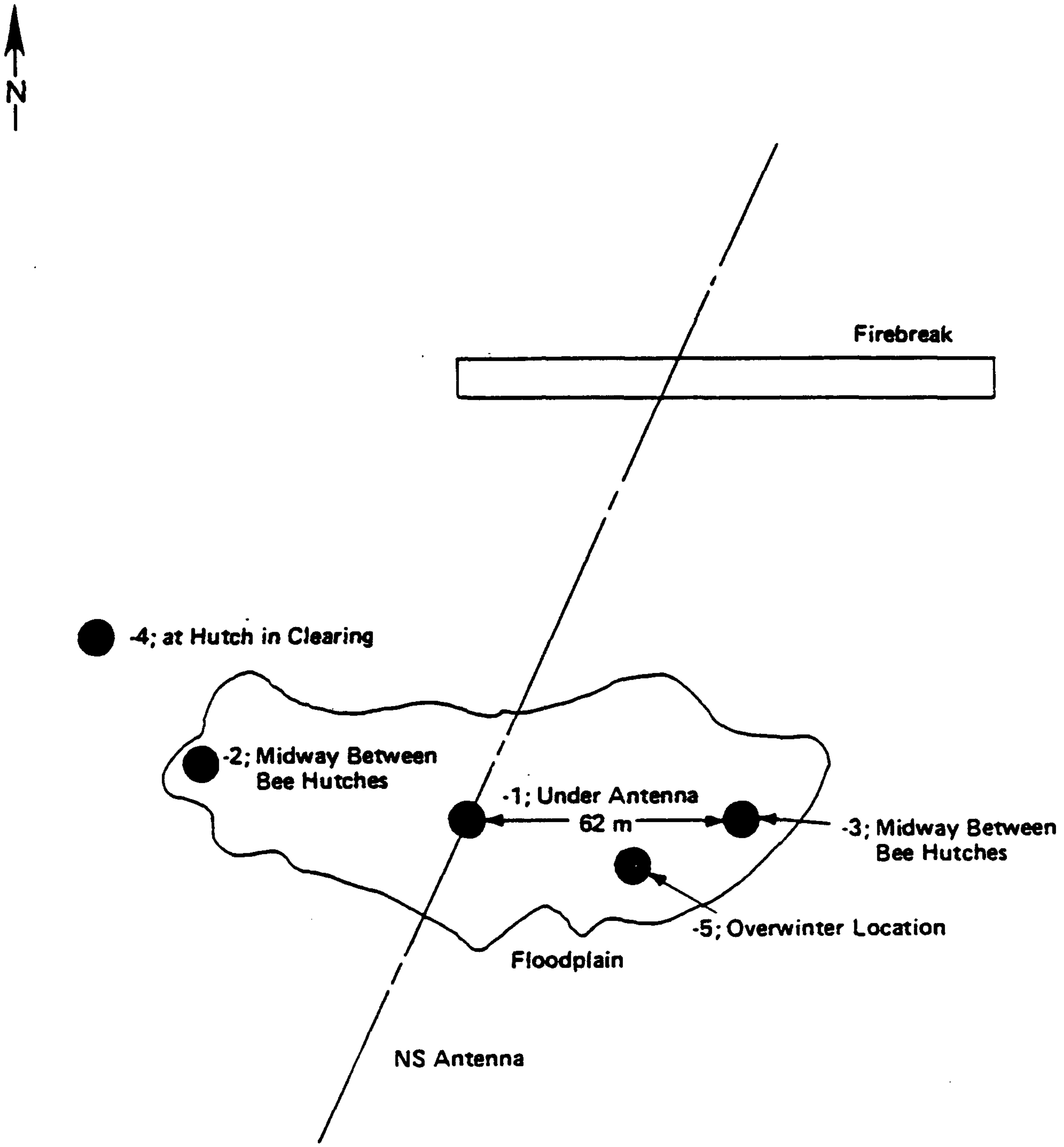



FIGURE B-4. MEASUREMENT POINTS AT FORD 1 (F1); 2T1-1, 2, 3, 4, 5.

60297/790

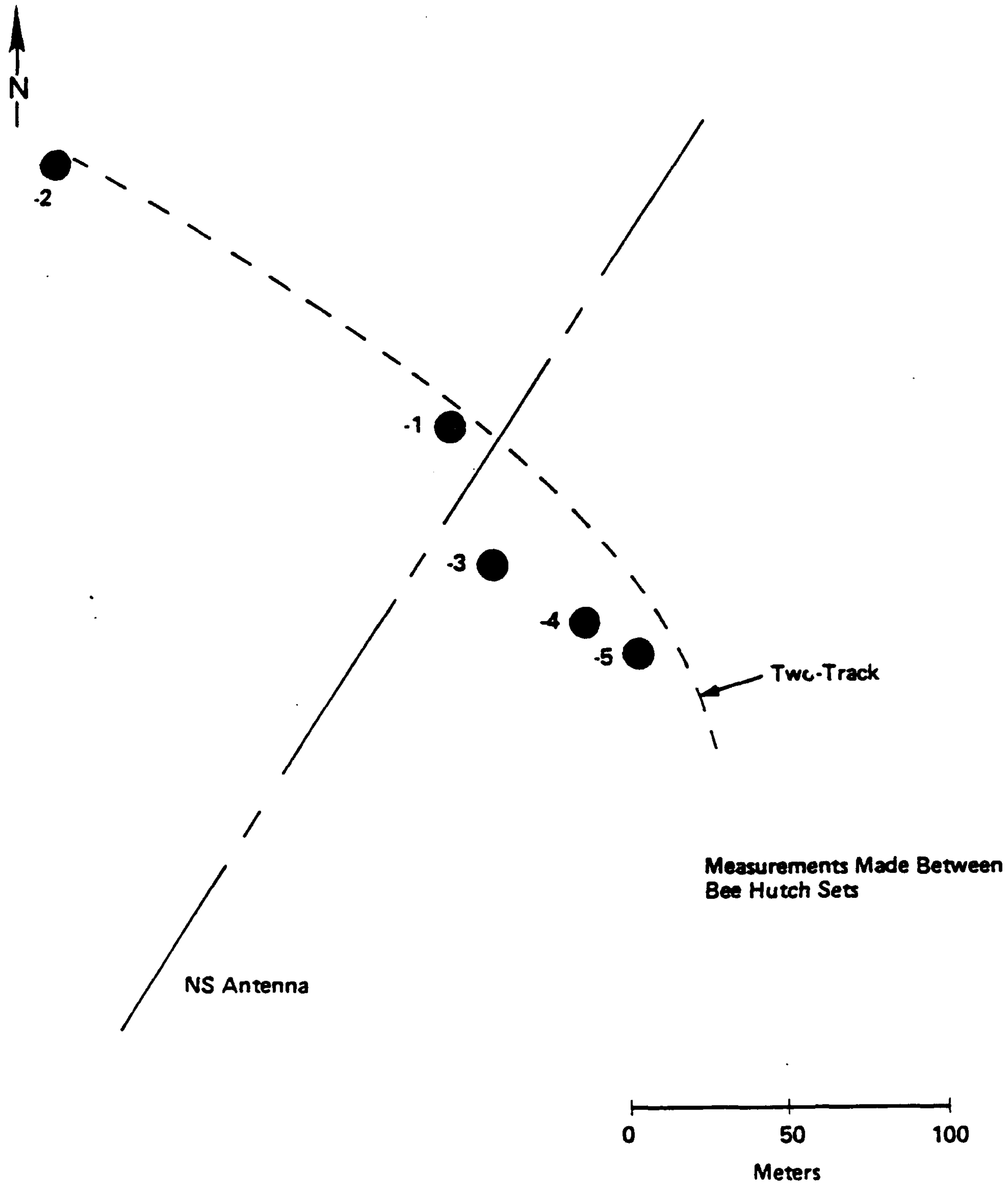



FIGURE B-5. MEASUREMENT POINTS AT FORD 2 (F2); 2T2-1 THROUGH 5.

60297/790

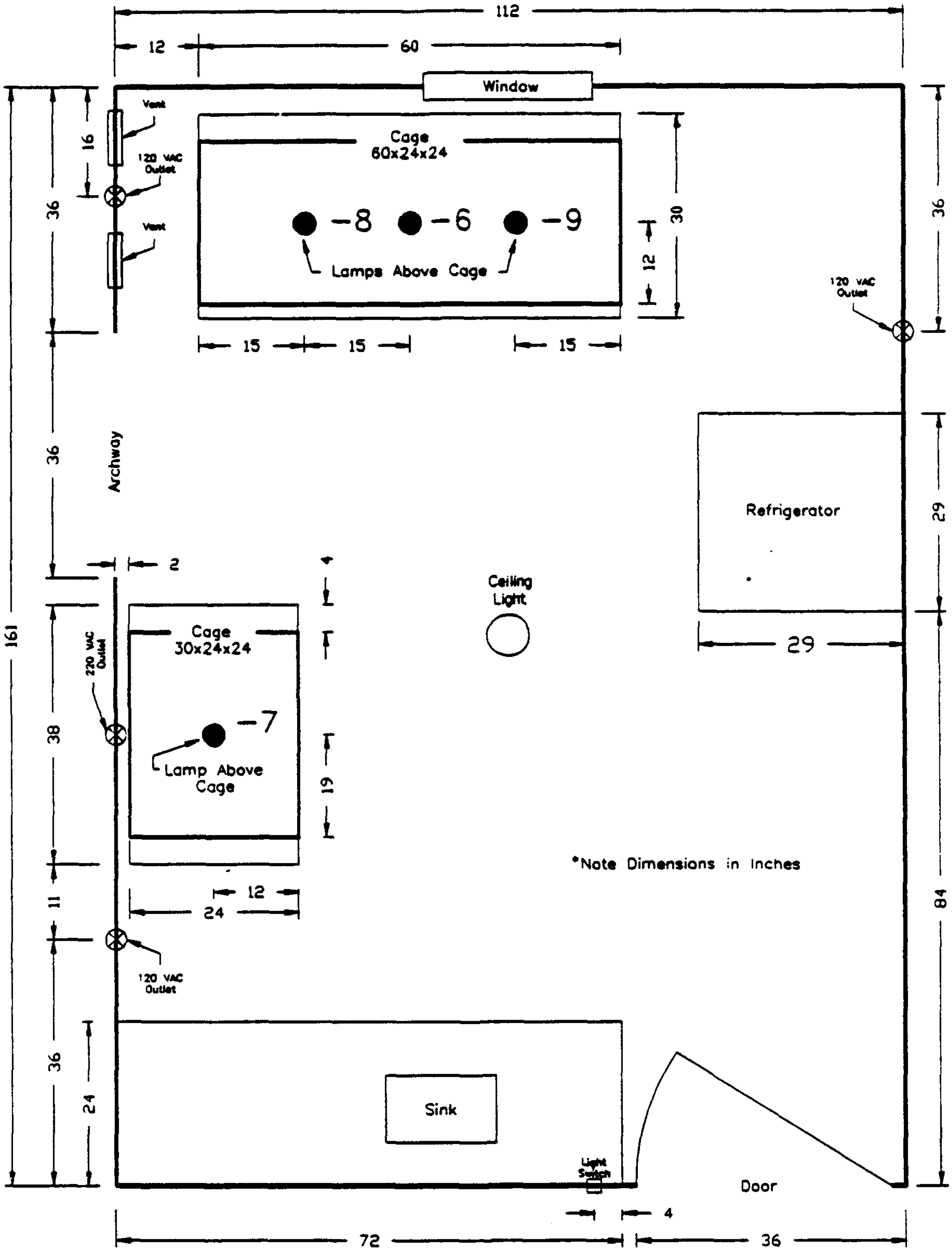



**FIGURE B-6. MEASUREMENT POINTS AT CRYSTAL FALLS LABORATORY, 2ND FLOOR WORK AREA; 2L1-6 THROUGH 9.**

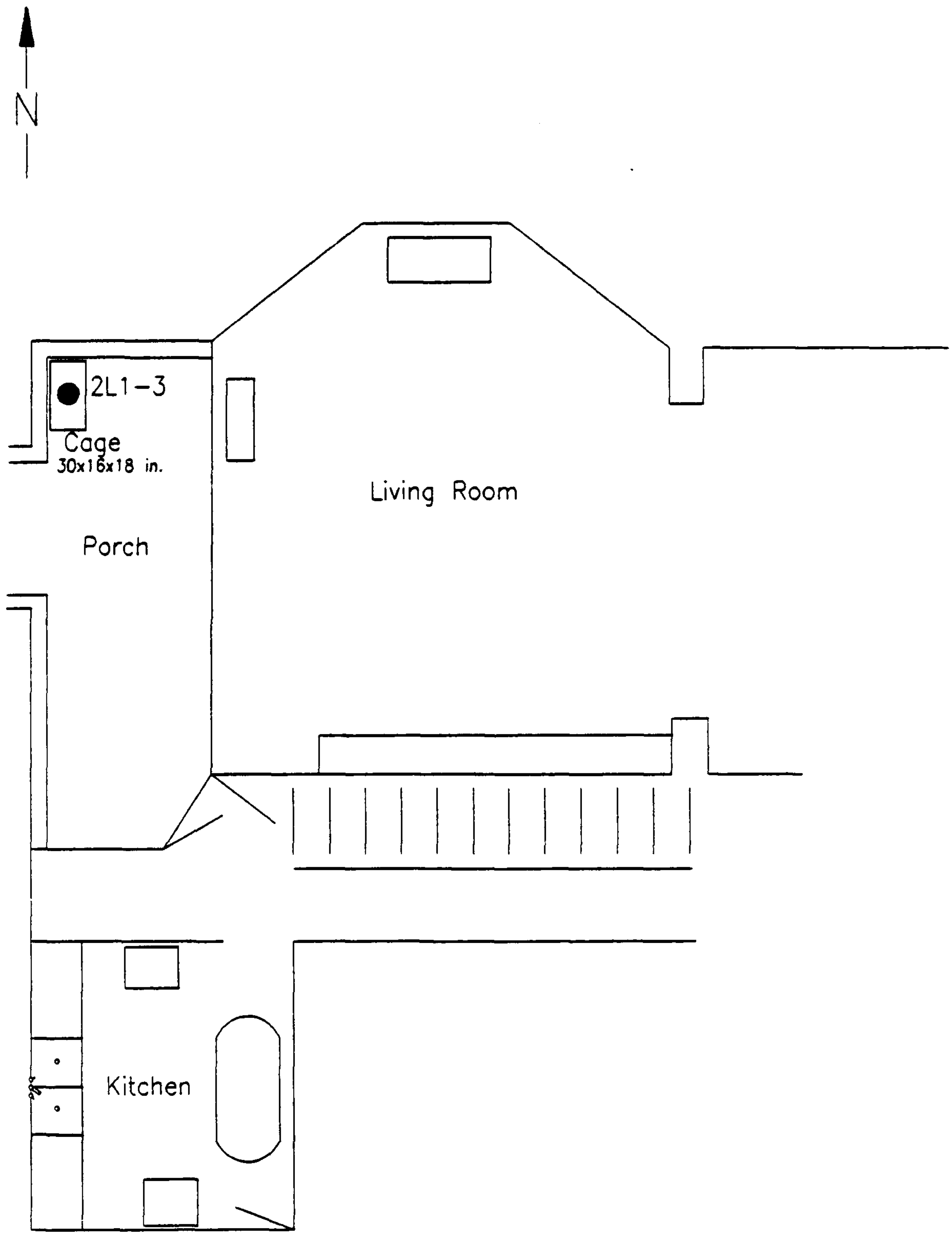



**FIGURE B-7. MEASUREMENT POINT AT CRYSTAL FALLS LABORATORY, GROUND LEVEL; 2L1-3.**

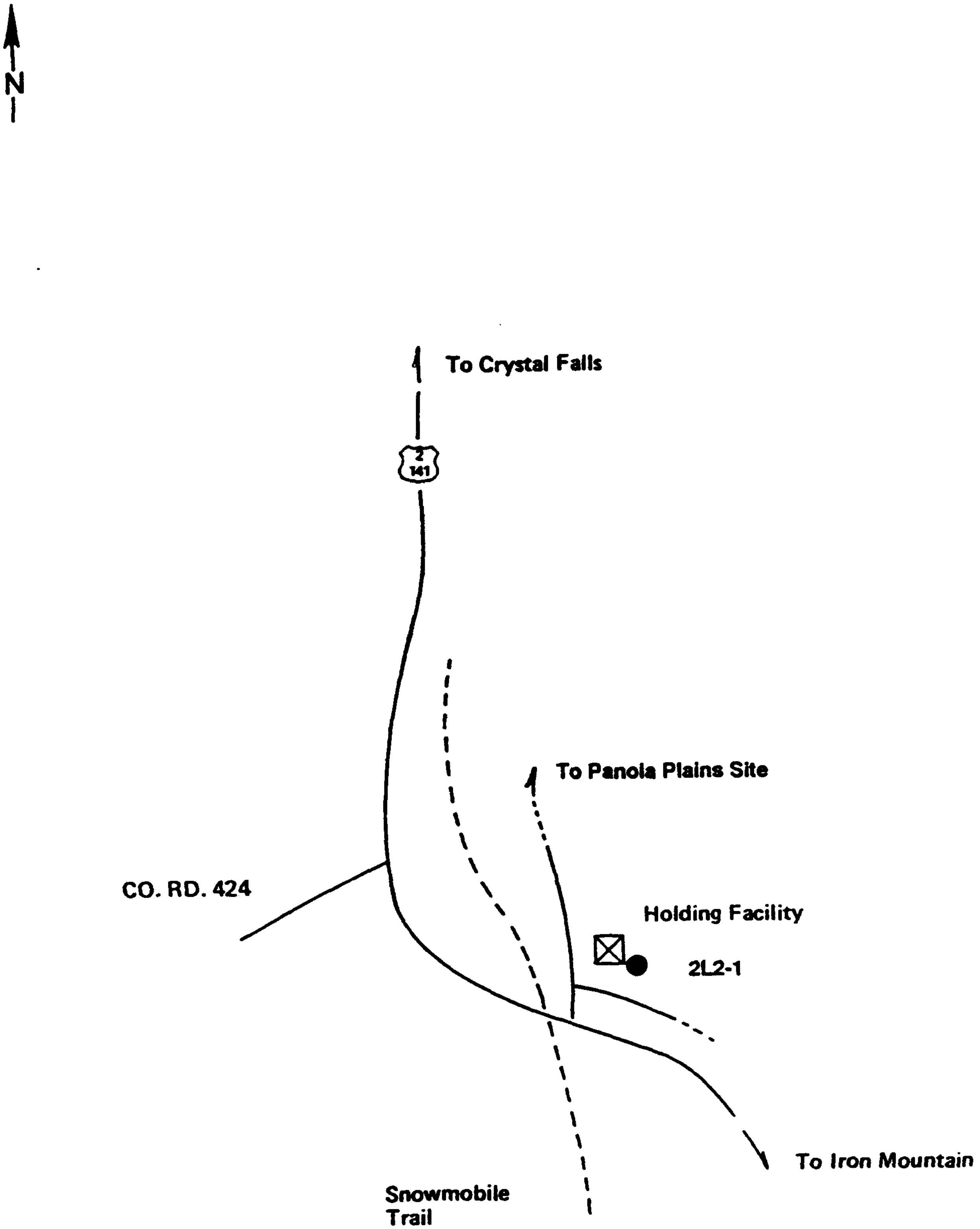



FIGURE B-8. MEASUREMENT POINT AT REMOTE HOLDING FACILITY; 2L2-1.

TABLE B-3. 60 Hz AIR ELECTRIC FIELD INTENSITIES (V/m)
Native Bees Studies

| Site No., Meas. Pt. | 1983[a] | 1984[a] | 1985[a] | 1986[b] | 1987[c] | 1988[c] | 1989[d] | 1990 |
|---|---|---|---|---|---|---|---|---|
| 2C4-1 | <0.001 | <0.001 | < | < | < | < | < | <[d] |
| 2C4-2 | - | - | < | < | < | < | < | <[d] |
| 2C5-1 | - | <0.001 | < | < | < | < | < | <[d] |
| 2C5-2 | - | <0.001 | < | < | < | < | < | <[d] |
| 2C5-4 | - | - | < | < | < | < | < | <[d] |
| 2L2-1 | - | - | - | - | - | < | < | <[d] |
| 2T1-1 | 0.004 | <0.001 | < | < | 0.074 | 0.13 | # | 0.043[b] |
| 2T1-2 | - | - | - | < | <0.001 | 0.001 | # | <0.001[b] |
| 2T1-3 | - | - | - | < | <0.001 | 0.001 | # | <0.001[b] |
| 2T1-4 | - | - | - | - | < | <0.001 | # | <[b] |
| 2T1-5 | - | - | - | - | < | 0.006 | # | 0.001[b] |
| 2T2-1 | <0.001 | <0.001,0.001 | < | < | 0.024 | 0.079 | # | 0.024,0.048[b,c] |
| 2T2-2 | - | - | - | < | <0.001 | <0.001 | # | <[b] |
| 2T2-3 | - | - | - | < | 0.023 | 0.087 | # | 0.018[b] |
| 2T2-4 | - | - | - | < | 0.003 | 0.012 | # | 0.002[b] |
| 2T2-5 | - | - | - | < | 0.002 | 0.005 | # | 0.001[b] |

a = antennas not constructed.
b = antennas off, grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 A current.

- = measurement point not established.
# = measurement precluded by antenna operation.
< = measurement est. <0.001 V/m based on earth E-field.

TABLE B-4. 60 Hz EARTH ELECTRIC FIELD INTENSITES (mV/m)
Native Bees Studies

| Site No., Meas. Pt. | 1983[a] | 1984[a] | 1985[a] | 1986[b] | 1987[c] | 1988[c] | 1989[d] | 1990 |
|---|---|---|---|---|---|---|---|---|
| 2C4-1 | 0.011 | 0.102, 0.138, 0.160 | 0.104 | 0.133 | 0.178 | 0.134 | 0.095 | 0.098[d] |
| 2C4-2 | - | - | 0.21 | 0.21 | 0.26 | 0.23 | 0.169 | 0.095[d] |
| 2C5-1 | - | 0.64, 0.50, 0.93 | 0.69 | 0.49 | 0.38 | 0.23 | 0.21 | 0.37[d] |
| 2C5-2 | - | 0.23 | 0.40 | 0.160 | 0.23 | 0.099 | 0.139 | 0.26[d] |
| 2C5-4 | - | - | 0.148 | 0.090 | 0.098 | 0.078 | 0.078 | 0.145[d] |
| 2L2-1 | - | - | - | - | - | 0.019 | 0.022,0.013 | 0.022[d] |
| 2T1-1 | 0.23 | 0.26 | 0.22 | 0.042 | 0.092 | 0.108 | # | 0.062[b] |
| 2T1-2 | - | - | - | 0.051 | 0.034 | 0.053 | # | 0.024[b] |
| 2T1-3 | - | - | - | 0.077 | 0.051 | 0.059 | # | 0.052[b] |
| 2T1-4 | - | - | - | - | 0.040 | 0.152 | # | 0.040[b] |
| 2T1-5 | - | - | - | - | 0.050 | 0.151 | # | 0.023[b] |
| 2T2-1 | 0.071 | 0.65,0.88 | 0.86,0.88 | 0.23 | 0.54 | 1.49 | # | 0.38,0.90[b,c] |
| 2T2-2 | - | - | - | 0.092 | 0.100 | 1.31 | # | 0.20[b] |
| 2T2-3 | - | - | - | 0.123 | 0.25 | 0.84 | # | 0.175[b] |
| 2T2-4 | - | - | - | 0.078 | 0.186 | 0.67 | # | 0.161[b] |
| 2T2-5 | - | - | - | 0.120 | 0.23 | 1.11 | # | 0.22[b] |

a = antennas not constructed.
b = antennas off, grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 A current.

\- = measurement point not established.
\# = measurement precluded by antenna operation.

TABLE B-5. 60 Hz MAGNETIC FLUX DENSITIES (mG)
Native Bees Studies

| Site No., Meas. Pt. | 1983[a] | 1984[a] | 1985[a] | 1986[b] | 1987[c] | 1988[c] | 1989[d] | 1990 |
|---|---|---|---|---|---|---|---|---|
| 2C4-1 | 0.004 | 0.003,0.004 | 0.003 | 0.003 | 0.006 | 0.006 | 0.005 | 0.006[d] |
| 2C4-2 | - | - | 0.003 | 0.003 | 0.005 | 0.003 | 0.004 | 0.005[d] |
| 2C5-1 | - | 0.001,0.002 | 0.002 | 0.001 | 0.002 | 0.001 | 0.001 | 0.002[d] |
| 2C5-2 | - | <0.001 | 0.002 | 0.001 | 0.002 | 0.001 | 0.001 | 0.002[d] |
| 2C5-4 | - | - | 0.002 | 0.002 | 0.002 | 0.001 | 0.001 | 0.002[d] |
| 2L2-1 | - | - | - | - | - | 0.003 | 0.002,0.002 | 0.002[d] |
| 2T1-1 | 0.001 | 0.002 | 0.001 | 0.038 | 0.042 | 0.075 | # | 0.020[b] |
| 2T1-2 | - | - | - | 0.004 | 0.008 | 0.012 | # | 0.004[b] |
| 2T1-3 | - | - | - | 0.005 | 0.019 | 0.018 | # | 0.004[b] |
| 2T1-4 | - | - | - | - | 0.006 | 0.010 | # | 0.001[b] |
| 2T1-5 | - | - | - | - | 0.011 | 0.027 | # | 0.005[b] |
| 2T2-1 | 0.002 | 0.001 | 0.001 | 0.020 | 0.058 | 0.134 | # | 0.033,0.070[b,c] |
| 2T2-2 | - | - | - | 0.003 | 0.008 | 0.022 | # | 0.004[b] |
| 2T2-3 | - | - | - | 0.015 | 0.038 | 0.115 | # | 0.028[b] |
| 2T2-4 | - | - | - | 0.006 | 0.018 | 0.058 | # | 0.012[b] |
| 2T2-5 | - | - | - | 0.005 | 0.013 | 0.044 | # | 0.010[b] |

a = antennas not constructed.
b = antennas off, grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 A current.

- = measurement point not established.
# = measurement precluded by antenna operation.

TABLE B-6. 76 Hz AIR ELECTRIC FIELD INTENSITIES (V/m)
Native Bees Studies

| SITE NO., MEAS.PT. | 1986 NS 4 amps | 1986 NEW 6 amps | 1986 SEW 6 amps | 1986 SEW 10 amps (EX) | 1987 NS 15 amps | 1987 EW 15 amps | 1988 NS 75 amps | 1988 EW 75 amps | 1989 B 150 amps | 1990 B 150 amps |
|---|---|---|---|---|---|---|---|---|---|---|
| 2C4-1 | < | < | < | * | < | < | < | < | < | < |
| 2C4-2 | < | < | < | * | < | < | < | < | < | < |
| 2C5-1 | < | < | < | * | < | < | < | < | < | < |
| 2C5-2 | < | < | < | * | < | < | < | < | < | < |
| 2C5-4 | < | < | < | * | < | < | < | < | < | < |
| 2L2-1 | - | - | - | - | - | - | < | < | < | < |
| 2T1-1 | 0.59 | < | < | * | 2.9 | 0.003 | 15.8 | 0.056 | 23 | 42 |
| 2T1-2 | 0.009 | < | < | * | 0.022 | < | 0.135 | <0.001 | 0.23 | 0.46 |
| 2T1-3 | 0.005 | < | < | * | 0.019 | < | 0.095 | 0.001 | 0.178 | 0.40 |
| 2T1-4 | - | - | - | - | 0.007 | < | 0.027 | 0.001 | 0.054 | 0.075 |
| 2T1-5 | - | - | - | - | / | / | 0.39 | 0.002 | 0.63 | 1.23 |
| 2T2-1 | 0.182 | < | < | * | 0.48 | <0.001 | 2.4 | 0.010 | 4.9 | 6.22 |
| 2T2-2 | 0.005 | < | < | * | 0.015 | <0.001 | 0.079 | 0.001 | 0.142 | 0.159 |
| 2T2-3 | 0.123 | < | < | * | 0.42 | <0.001 | 2.7 | 0.002 | 4.9 | 4.3 |
| 2T2-4 | 0.021 | < | < | * | 0.061 | <0.001 | 0.38 | 0.002 | 0.54 | 0.57 |
| 2T2-5 | 0.012 | < | < | * | 0.039 | <0.001 | 0.159 | <0.001 | 0.29 | 0.32 |

NS = north-south antenna.
EW = east-west antenna.
NEW = northern EW antenna element.
SEW = southern EW antenna element.
B = NS + EW antennas, standard phasing.
EX = extrapolated data.

- = measurement point not established.
/ = measurement not taken.
< = measurement est. <0.001 V/m based on earth E-field.
* = data cannot be extrapolated.

TABLE B-7. 76 Hz EARTH ELECTRIC FIELD INTENSITIES (mV/m)
Native Bees Studies

| SITE NO., MEAS.PT. | 1986 | | | | 1987 | | 1988 | | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|---|
| | NS 4 amps | NEW 6 amps | SEW 6 amps | SEW 10 amps (EX) | NS 15 amps | EW 15 amps | NS 75 amps | EW 75 amps | B 150 amps | B 150 amps |
| 2C4-1 | / | / | / | * | 0.006 | 0.003 | 0.027 | 0.017 | 0.072 | 0.065 |
| 2C4-2 | 0.002 | 0.001 | 0.001 | 0.002 | 0.006 | 0.004 | 0.030 | 0.022 | 0.105 | 0.103 |
| 2C5-1 | 0.008 | 0.004 | 0.006 | 0.010 | 0.022 | 0.018 | 0.112 | 0.110 | 0.36 | 0.33 |
| 2C5-2 | / | / | / | * | 0.008 | 0.008 | 0.041 | 0.042 | 0.179 | 0.197 |
| 2C5-4 | / | / | / | * | 0.001 | 0.005 | 0.020 | 0.027 | 0.114 | 0.113 |
| 2L2-1 | - | - | - | - | - | - | 0.006 | 0.002 | 0.013 | 0.020 |
| 2T1-1 | 1.97 | 0.064 | 0.108 | 0.180 | 8.2 | 0.23 | 24 | 0.77 | 70 | 54 |
| 2T1-2 | 1.08 | 0.037 | 0.070 | 0.117 | 3.3 | 0.21 | 13.1 | 0.98 | 32 | 38 |
| 2T1-3 | 1.31 | 0.051 | 0.101 | 0.168 | 5.2 | 0.33 | 23 | 1.40 | 45 | 53 |
| 2T1-4 | - | - | - | - | 4.5 | 0.191 | 30 | 1.38 | 59 | 67 |
| 2T1-5 | - | - | - | - | / | / | 22 | 0.96 | 36 | 26 |
| 2T2-1 | 5.4 | 0.159 | 0.086 | 0.143 | 32. | 0.25 | 102 | 1.03 | 169 | 122 |
| 2T2-2 | 1.63 | 0.054 | 0.067 | 0.112 | 6.0 | 0.178 | 87 | 1.41 | 120 | 177 |
| 2T2-3 | 3.0 | 0.087 | 0.063 | 0.105 | 13.5 | 0.21 | 56 | 0.76 | 147 | 139 |
| 2T2-4 | 1.93 | 0.053 | 0.071 | 0.118 | 10.4 | 0.25 | 43 | 1.04 | 95 | 85 |
| 2T2-5 | 3.6 | 0.101 | 0.096 | 0.160 | 14.0 | 0.24 | 75 | 1.05 | 188 | 145 |

NS = north-south antenna.
EW = east-west antenna.
NEW = northern EW antenna element.
SEW = southern EW antenna element.
B = NS + EW antennas, standard phasing.
EX = extrapolated data.

\- = measurement point not established.
/ = measurement not taken.
* = data cannot be extrapolated.

TABLE B-8. 76 Hz MAGNETIC FLUX DENSITIES (mG)
Native Bees Studies

| SITE NO., MEAS.PT. | 1986 NS 4 amps | 1986 NEW 6 amps | 1986 SEW 6 amps | 1986 SEW 10 amps (EX) | 1987 NS 15 amps | 1987 EW 15 amps | 1988 NS 75 amps | 1988 EW 75 amps | 1989 B 150 amps | 1990 B 150 amps |
|---|---|---|---|---|---|---|---|---|---|---|
| 2C4-1 | / | / | / | * | 0.001 | <0.001 | 0.002 | 0.001 | 0.006 | 0.006 |
| 2C4-2 | <0.001 | <0.001 | <0.001 | * | 0.001 | <0.001 | 0.003 | 0.001 | 0.006 | 0.007 |
| 2C5-1 | <0.001 | <0.001 | <0.001 | * | <0.001 | <0.001 | 0.001 | 0.001 | 0.002 | 0.003 |
| 2C5-2 | / | / | / | * | <0.001 | <0.001 | 0.001 | 0.001 | 0.002 | 0.003 |
| 2C5-4 | / | / | / | * | <0.001 | <0.001 | 0.001 | 0.001 | 0.003 | 0.003 |
| 2L2-1 | - | - | - | - | - | - | <0.001 | <0.001 | 0.002 | 0.002 |
| 2T1-1 | 0.77 | 0.024 | 0.004 | 0.007 | 3.1 | 0.004 | 14.4 | 0.052 | 31 | 29 |
| 2T1-2 | 0.125 | 0.004 | <0.001 | * | 0.46 | 0.002 | 2.1 | 0.007 | 4.5 | 4.5 |
| 2T1-3 | 0.131 | 0.004 | 0.001 | 0.002 | 0.53 | 0.001 | 2.5 | 0.014 | 5.1 | 5.2 |
| 2T1-4 | - | - | - | - | 0.33 | 0.002 | 1.47 | 0.006 | 3.0 | 3.0 |
| 2T1-5 | - | - | - | - | / | / | 3.2 | 0.016 | 6.6 | 6.4 |
| 2T2-1 | 0.40 | 0.013 | 0.002 | 0.003 | 1.51 | 0.004 | 7.2 | 0.021 | 14.7 | 14.7 |
| 2T2-2 | 0.060 | 0.002 | <0.001 | * | 0.22 | 0.002 | 1.05 | 0.005 | 2.1 | 2.1 |
| 2T2-3 | 0.35 | 0.011 | 0.002 | 0.003 | 1.33 | 0.002 | 6.2 | 0.026 | 12.8 | 12.8 |
| 2T2-4 | 0.158 | 0.005 | 0.001 | 0.002 | 0.58 | 0.001 | 2.9 | 0.015 | 5.5 | 5.7 |
| 2T2-5 | 0.124 | 0.004 | 0.001 | 0.002 | 0.46 | 0.001 | 2.2 | 0.013 | 4.4 | 4.4 |

NS = north-south antenna.
EW = east-west antenna.
NEW = northern EW antenna element.
SEW = southern EW antenna element.
B = NS + EW antennas, standard phasing.
EX = extrapolated data.

\- = measurement point not established.
/ = measurement not taken.
* = data cannot be extrapolated.

TABLE B-9. 60 Hz AIR ELECTRIC FIELD INTENSITIES
Native Bees Studies Laboratory

| Measurement Point | 1988 | 1989 | 1990 | | | |
|---|---|---|---|---|---|---|
| Identification | E-Field (V/m) | E-Field (V/m) | Hatches | Lamps | Workers | E-Field (V/m) |
| 2L1-1 | 79 | 31 | N/A | N/A | N/A | -- |
| 2L1-2 | 22 | 19.5 | N/A | N/A | N/A | -- |
| 2L1-3 | 0.25 | 0.45 | CLOSED | N/A | N/A | 0.001 |
| | | | OPEN | N/A | N/A | 0.023 |
| 2L1-4 | - | 12.5 | N/A | N/A | N/A | -- |
| 2L1-5 | - | 18.2 | N/A | N/A | N/A | -- |
| 2L1-6 (no cage) | - | 5.3 | N/A | ON | NONE | 14.9 |
| 2L1-7 (no cage) | - | - | N/A | N/A | N/A | 22 |
| 2L1-7 | - | - | CLOSED | ON | NONE | 0.039 |
| | | | OPEN | ON | NONE | 1.14 |
| | | | OPEN | ON | 1-Not grounded to cage | 15.7 |
| | | | OPEN | ON | 1-Not grounded to cage | 0.122-0.198 |
| 2L1-8 | - | - | CLOSED | ON | NONE | 0.039 |
| | | | OPEN | ON | NONE | 0.84 |
| | | | OPEN | ON | 2-Grounded to cage | 0.122-0.198 |
| 2L1-9 | - | - | CLOSED | ON | NONE | 0.040 |
| | | | OPEN | ON | NONE | 0.88 |
| | | | OPEN | ON | 2-Grounded to cage | 0.122-0.198 |

- = measurement point not established.
-- = measurement point dropped.

**TABLE B-10. 60 Hz MAGNETIC FLUX DENSITIES (mG)**
**Native Bees Studies Laboratory**

| Measurement Point Identification | 1988 | 1989 | 1990 |
|---|---|---|---|
| 2L1-1 | 0.93 | 0.75 | – |
| 2L1-2 | 0.52 | 0.39 | – |
| 2L1-3 | 0.37 | 0.43 | 0.33 |
| 2L1-4 | - | 0.32 | – |
| 2L1-5 | - | 0.32 | – |
| 2L1-6 | - | 0.30 | / |
| 2L1-7 | - | - | 0.26 |
| 2L1-8 | - | - | 0.38 |
| 2L1-9 | - | - | 0.40 |

\- = measurement point not established.
– = measurement point dropped.
/ = data not taken.

## APPENDIX C

## SOIL ARTHROPODS AND EARTHWORMS STUDIES

## SOIL ARTHROPODS AND EARTHWORMS STUDIES

These studies monitor the species composition, population age structure, and distribution of soil arthropods and earthworms. The electric and magnetic fields in the earth are considered the most important electromagnetic (EM) factors influencing soil biota. The electric field in the air is not expected to have a significant impact on the objectives of these studies.

IITRI field crews made ELF EM field measurements at eight measurement points within the single treatment and single control site for the soil arthropods and earthworms studies in 1990. The study sites and the measurement points within those sites were unchanged from 1989. Measurement dates for 1990 and previous years appear in Table C-1.

The positions of the two sites relative to the NRTF-Republic are shown on the composite map in Figure C-1. The site numbers listed on the map are those used by IITRI. Table C-2 provides a cross-reference of IITRI site numbers, investigator site names, and township, range, and section numbers for the sites. Details of measurement locations within sites are shown in Figures C-2 and C-3.

EM field measurements for 1990 and previous years are found in Tables C-3 through C-8. Tables C-3, C-4, and C-5 present 60 Hz data for the air electric field, earth electric field, and magnetic flux density, respectively. Tables C-6, C-7, and C-8 present 76 Hz data for these fields as well as the corresponding operating currents of the NRTF-Republic for each year.

**Table C-1. EM FIELD MEASUREMENT DATES**
**Soil Arthropods and Earthworms Studies**

| Year | Measurement Dates | |
|---|---|---|
| 1983 | Jun 6 | Jul 13 |
| 1984 | May 14, 21 | Aug 9, 13 |
| 1985 | Jul 19 | |
| 1986 | Oct 2, 7 | |
| 1987 | Sep 25, 28 | |
| 1988 | Sep 26 | Oct 3 |
| 1989 | Sep 13, 15 | |
| 1990 | Oct 2, 8 | |

**TABLE C-2. SITE NO. CROSS-REFERENCE**
**Soil Arthropods and Earthworms Studies**

| IITRI Site No. | Investigator's Site Name | Location Township | : | Range | : | Section(s) |
|---|---|---|---|---|---|---|
| 3T2 | South Silver Lake | T44N | : | R29W | : | 25 |
| 3C5 | Turner Road | T43N | : | R30W | : | 11 |

Considerable year-to-year variability in the 60 Hz EM fields is evident. The primary factors in this variability are changes in power line loading conditions (which are unknown) and differences in the configuration of the antennas at the time of measurement. Notes on the antenna configurations are included in the tables primarily for engineering use. The 60 Hz measurements in 1986, 1987, 1988, and 1990 were taken while the antennas were off, and are representative of 60 Hz levels present during maintenance periods. In 1989, measurements were taken at the treatment site during full-power operation of the antennas with a unmodulated signal. These values indicate that 60 Hz EM fields present during operation of the antennas are comparable to those present when the antennas are off.

Annual variations in the 60 Hz fields measured at the control study sites are also caused by differences in power line loading, but are not dependent on the antennas or their configuration because of the distance of these sites from the antennas. The 60 Hz field values at the control site, nonetheless, are about as variable as those at the treatment site.

Overall, the 60 Hz EM fields measured at both study sites in 1990 are consistent with previous field values and with the expected differences in power line loads and the antenna configuration. Regardless of the field variability associated with the measurement condition, 76 Hz EM fields at the treatment site consistently dominate the 60 Hz EM fields at both the treatment and control sites, and the ratios of 60 Hz EM fields between the treatment and control sites continue to meet exposure criteria guidelines established at the beginning of the study.

The 76 Hz EM field measurements in 1990 were made with 150 ampere antenna currents, the predominant operating current of the NRTF-Republic since 4 May 1989. The antenna currents at which measurements were made in each year are given in the column headings of the Tables C-6 through C-8. The annual increases in field magnitudes reflect the level of antenna currents at the time of measurement: 4 or 6 amperes in 1986, 15 amperes in 1987, 75 amperes in 1988, and 150 amperes in 1989 and 1990. The 1990 measurements are consistent with the 1989 measurements at the same current, and proportional to the 1986, 1987, and 1988 measurements made at lower currents.

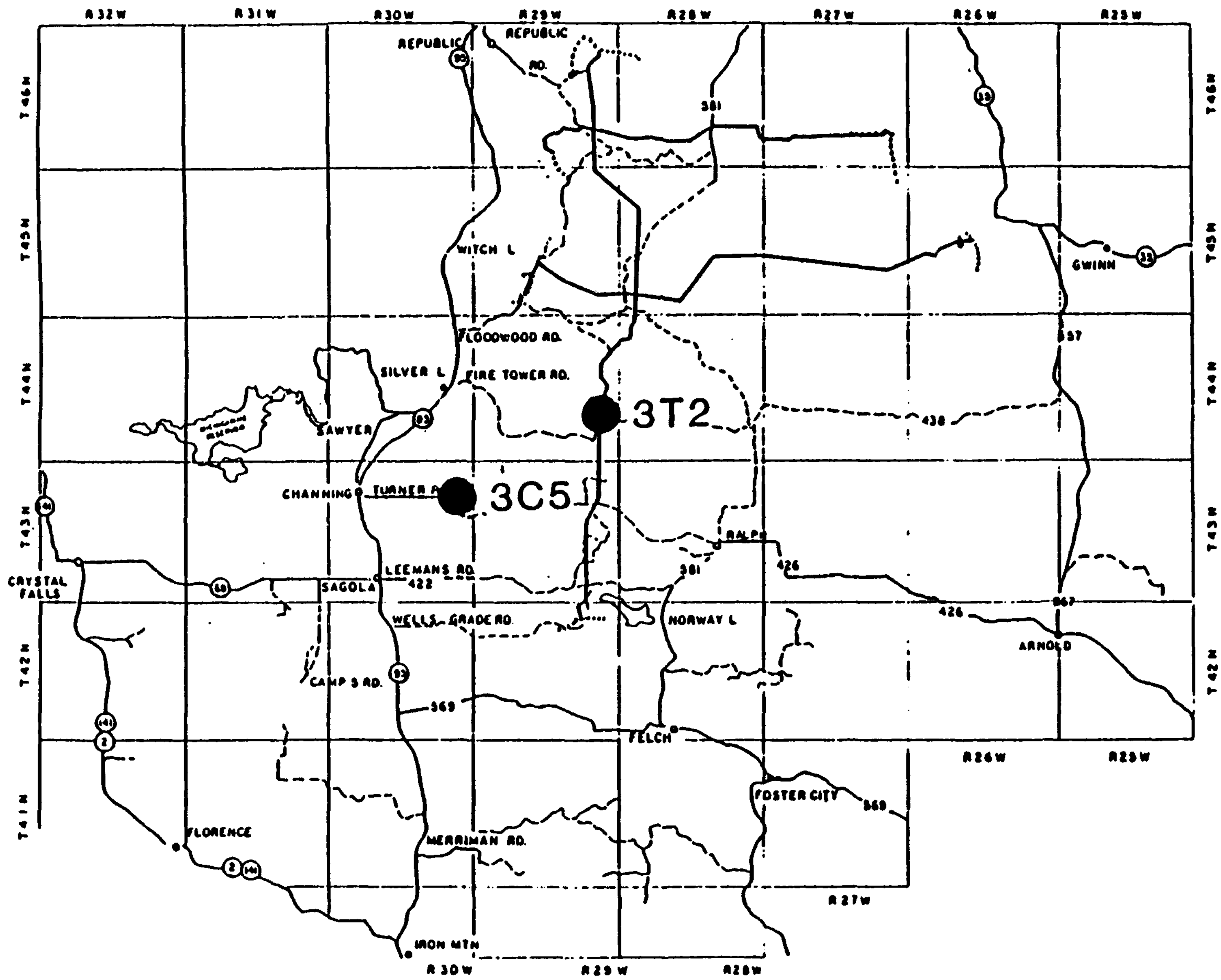



FIGURE C-1. POSITIONS OF SOIL ARTHROPODS AND EARTHWORMS STUDY SITES RELATIVE TO NRTF-REPUBLIC ANTENNA ELEMENTS.

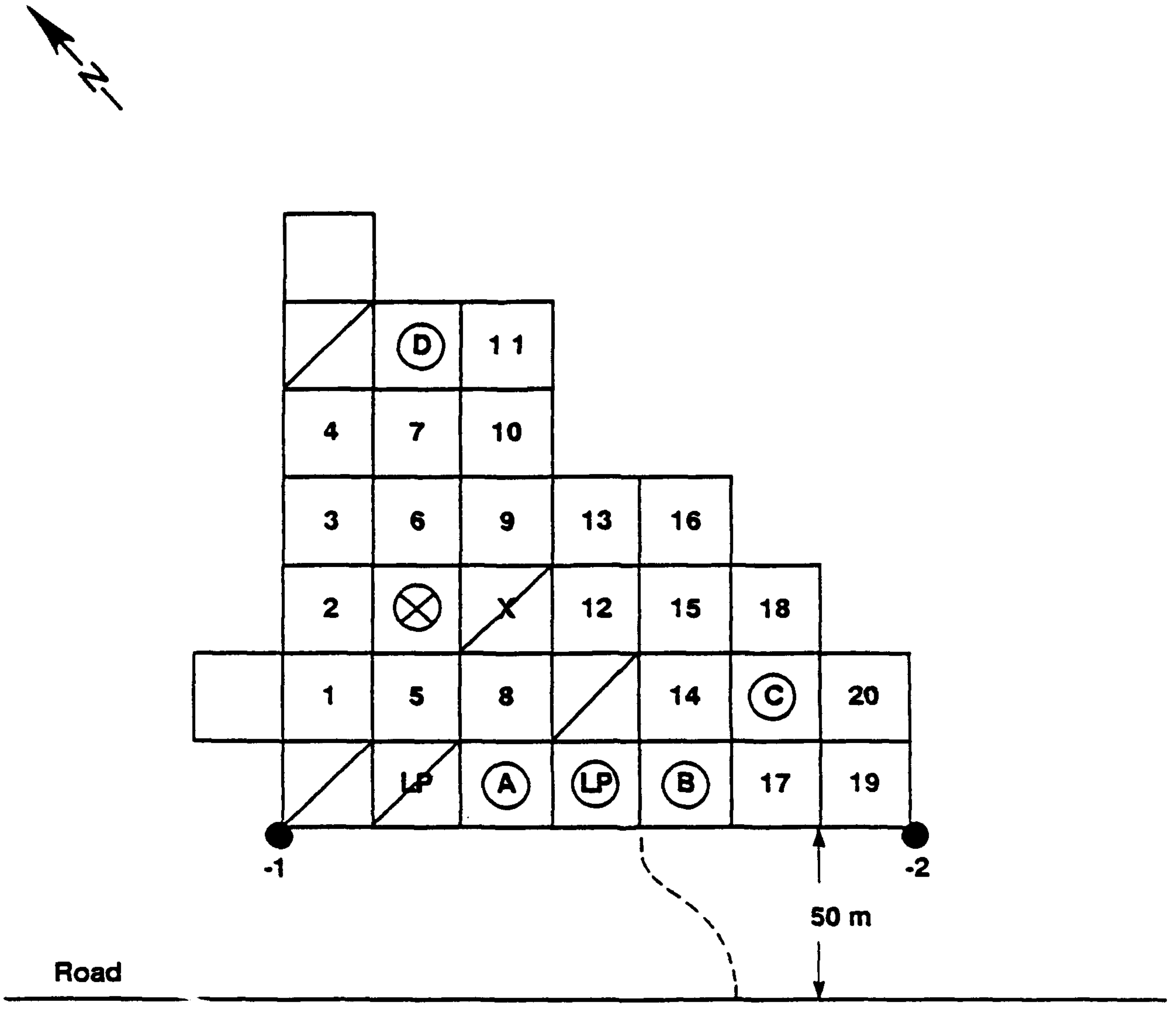



FIGURE C-2. MEASUREMENT POINTS AT TURNER ROAD; 3C5-1, 2.

60297/790

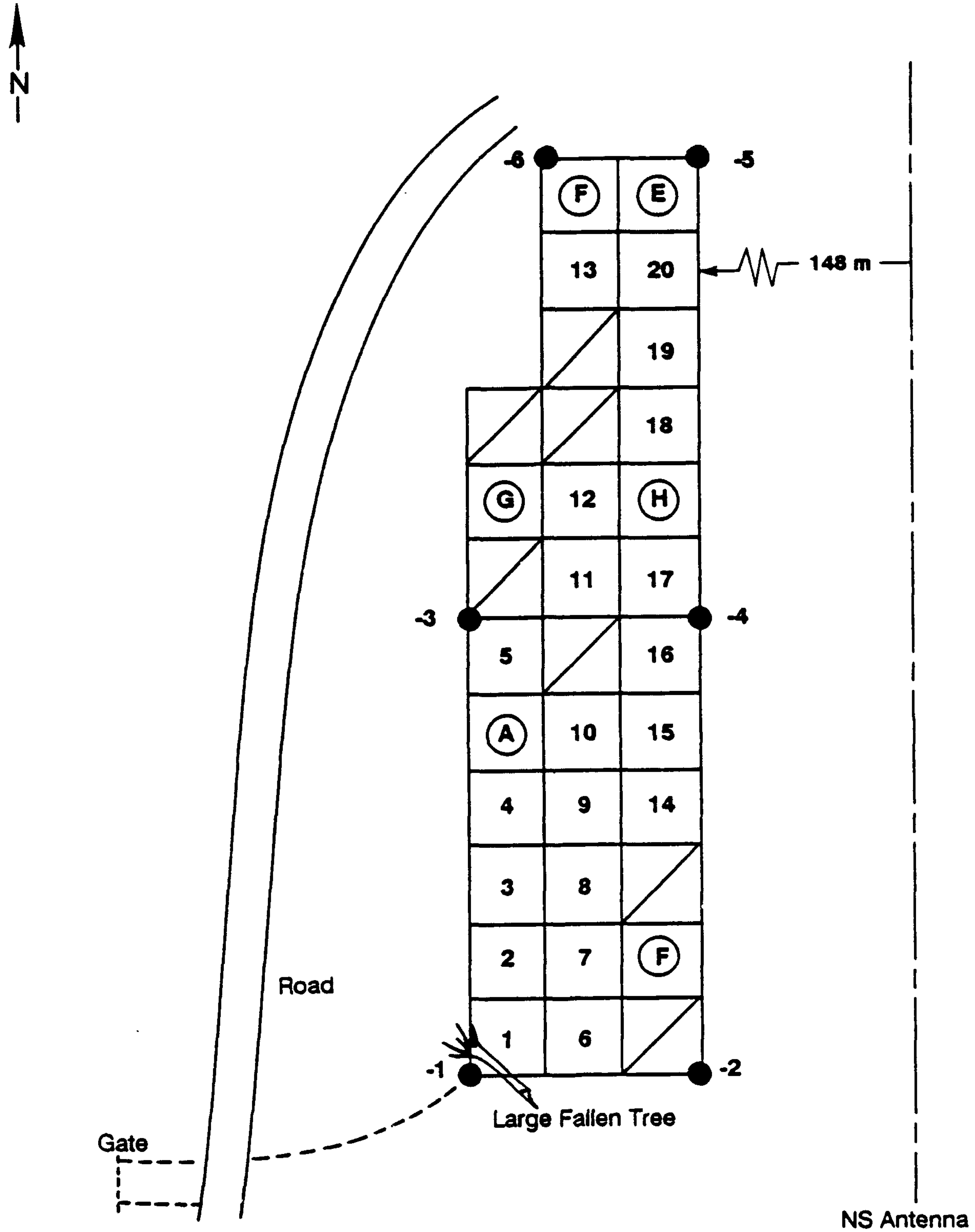



**FIGURE C-3. MEASUREMENT POINTS AT SOUTH SILVER LAKE; 3T2-1 THROUGH 6.**

TABLE C-3. 60 Hz AIR ELECTRIC FIELD INTENSITIES (V/m)
Soil Arthropods and Earthworms Studies

| Site No., Mea^ Pt. | 1983[a] | 1984[a] | 1985[a] | 1986[b] | 1987[c] | 1988[c] | 1989[d] | 1990 |
|---|---|---|---|---|---|---|---|---|
| 3C5-1 | <0.001 | <0.001 | < | < | < | < | < | <[d] |
| 3C5-2 | - | - | - | < | < | < | < | <[d] |
| 3T2-1 | <0.001 | <0.001 | < | < | < | < | <0.001 | <0.001[c] |
| 3T2-2 | - | - | - | < | < | < | < | <0.001[c] |
| 3T2-3 | - | - | - | < | < | < | < | <[c] |
| 3T2-4 | - | - | - | < | < | < | < | <[c] |
| 3T2-5 | - | - | - | < | < | < | < | <[c] |
| 3T2-6 | - | - | - | < | < | < | < | <[c] |

a = antennas not constructed.
b = antennas off, grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 A current.

- = measurement point not established.
< = measurement est. <0.001 V/m based on earth E-field.

TABLE C-4. 60 Hz EARTH ELECTRIC FIELD INTENSITES (mV/m)
Soil Arthropods and Earthworms Studies

| Site No., Meas. Pt. | 1983[a] | 1984[a] | 1985[a] | 1986[b] | 1987[c] | 1988[c] | 1989[d] | 1990 |
|---|---|---|---|---|---|---|---|---|
| 3C5-1 | 0.063 | 0.018,0.032 | 0.036 | 0.027 | 0.054 | 0.054 | 0.062 | 0.065[d] |
| 3C5-2 | - | - | - | 0.027 | 0.071 | 0.085 | 0.182 | 0.118[d] |
| 3T2-1 | 0.106 | 0.129,0.27 | 0.194 | 0.045 | 0.042 | 0.091 | 0.055 | 0.042[c] |
| 3T2-2 | - | - | - | 0.068 | 0.049 | 0.093 | 0.049 | 0.043[c] |
| 3T2-3 | - | - | - | 0.038 | 0.043 | 0.084 | 0.035 | 0.047[c] |
| 3T2-4 | - | - | - | 0.045 | 0.039 | 0.087 | 0.068 | 0.040[c] |
| 3T2-5 | - | - | - | 0.044 | 0.045 | 0.084 | 0.053 | 0.047[c] |
| 3T2-6 | - | - | - | 0.048 | 0.033 | 0.087 | 0.041 | 0.042[c] |

a = antennas not constructed.
b = antennas off, grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 A current.

- = measurement point not established.

TABLE C-5. 60 Hz MAGNETIC FLUX DENSITIES (mG)
Soil Arthropods and Earthworms Studies

| Site No., Meas. Pt. | 1983[a] | 1984[a] | 1985[a] | 1986[b] | 1987[c] | 1988[c] | 1989[d] | 1990 |
|---|---|---|---|---|---|---|---|---|
| 3C5-1 | 0.001 | 0.001 | 0.001 | 0.001 | 0.002 | 0.001 | 0.001 | 0.002[d] |
| 3C5-2 | - | - | - | <0.001 | 0.001 | 0.001 | 0.002 | 0.001[d] |
| 3T2-1 | <0.001 | <0.001 | 0.001 | 0.005 | 0.002 | 0.004 | 0.001 | 0.003[c] |
| 3T2-2 | - | - | - | 0.006 | 0.003 | 0.006 | 0.002 | 0.004[c] |
| 3T2-3 | - | - | - | 0.004 | 0.003 | 0.003 | 0.001 | 0.003[c] |
| 3T2-4 | - | - | - | 0.005 | 0.003 | 0.005 | 0.002 | 0.004[c] |
| 3T2-5 | - | - | - | 0.005 | 0.003 | 0.004 | 0.002 | 0.004[c] |
| 3T2-6 | - | - | - | 0.004 | 0.003 | 0.003 | 0.001 | 0.004[c] |

a = antennas not constructed.
b = antennas off, grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 A current.

- = measurement point not established.

TABLE C-6. 76 Hz AIR ELECTRIC FIELD INTENSITIES (V/m)
Soil Arthropods and Earthworms Studies

| SITE NO., MEAS.PT. | 1986 NS 4 amps | 1986 NEW 6 amps | 1986 SEW 6 amps | 1986 SEW 10 amps (EX) | 1987 NS 15 amps | 1987 EW 15 amps | 1988 NS 75 amps | 1988 EW 75 amps | 1989 B 150 amps | 1990 B 150 amps |
|---|---|---|---|---|---|---|---|---|---|---|
| 3C5-1 | < | < | < | * | < | < | < | < | < | < |
| 3C5-2 | < | < | < | * | < | < | < | < | < | < |
| 3T2-1 | 0.002 | < | < | * | 0.006 | < | 0.031 | 0.003 | 0.064 | 0.056 |
| 3T2-2 | 0.002 | < | < | * | 0.006 | < | 0.024 | 0.003 | 0.070 | 0.068 |
| 3T2-3 | 0.002 | < | < | * | 0.006 | < | 0.028 | 0.003 | 0.048 | 0.067 |
| 3T2-4 | 0.002 | < | < | * | 0.006 | < | 0.026 | 0.003 | 0.055 | 0.061 |
| 3T2-5 | 0.002 | < | < | * | 0.006 | < | 0.029 | 0.005 | 0.061 | 0.056 |
| 3T2-6 | 0.002 | < | < | * | 0.006 | < | 0.027 | 0.002 | 0.048 | 0.055 |

NS = north-south antenna.
EW = east-west antenna.
NEW = northern EW antenna element.
SEW = southern EW antenna element.
B = NS + EW antennas, standard phasing.
EX = extrapolated data.

< = measurement est. <0.001 V/m based on earth E-field.
* = data cannot be extrapolated.

TABLE C-7. 76 Hz EARTH ELECTRIC FIELD INTENSITIES (mV/m)
Soil Arthropods and Earthworms Studies

| SITE NO., MEAS.PT. | 1986 NS 4 amps | 1986 NEW 6 amps | 1986 SEW 6 amps | 1986 SEW 10 amps (EX) | 1987 NS 15 amps | 1987 EW 15 amps | 1988 NS 75 amps | 1988 EW 75 amps | 1989 B 150 amps | 1990 B 150 amps |
|---|---|---|---|---|---|---|---|---|---|---|
| 3C5-1 | 0.005 | 0.001 | 0.002 | 0.003 | 0.020 | 0.006 | 0.093 | 0.027 | 0.22 | 0.21 |
| 3C5-2 | 0.009 | 0.001 | 0.003 | 0.005 | 0.034 | 0.009 | 0.170 | 0.021 | 0.38 | 0.29 |
| 3T2-1 | 1.33 | 0.057 | 0.188 | 0.31 | 5.4 | 0.54 | 27 | 2.6 | 58 | 55 |
| 3T2-2 | 1.46 | 0.064 | 0.24 | 0.40 | 6.3 | 0.71 | 26 | 3.0 | 60 | 53 |
| 3T2-3 | 1.19 | 0.047 | 0.149 | 0.25 | 5.3 | 0.60 | 27 | 2.7 | 49 | 56 |
| 3T2-4 | 1.47 | 0.060 | 0.20 | 0.33 | 5.6 | 0.47 | 29 | 2.6 | 62 | 50 |
| 3T2-5 | 1.56 | 0.070 | 0.23 | 0.38 | 5.7 | 0.61 | 27 | 2.8 | 52 | 59 |
| 3T2-6 | 1.20 | 0.056 | 0.180 | 0.30 | 5.5 | 0.54 | 27 | 2.4 | 49 | 49 |

NS = north-south antenna.
EW = east-west antenna.
NEW = northern EW antenna element.
SEW = southern EW antenna element.
B = NS + EW antennas, standard phasing.
EX = extrapolated data.

TABLE C-8. 76 Hz MAGNETIC FLUX DENSITIES (mG)
Soil Arthropods and Earthworms Studies

| SITE NO., MEAS.PT. | 1986 | | | | 1987 | | 1988 | | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|---|
| | NS 4 amps | NEW 6 amps | SEW 6 amps | SEW 10 amps (EX) | NS 15 amps | EW 15 amps | NS 75 amps | EW 75 amps | B 150 amps | B 150 amps |
| 3C5-1 | <0.001 | <0.001 | <0.001 | * | 0.002 | 0.001 | 0.008 | 0.003 | 0.019 | 0.018 |
| 3C5-2 | <0.001 | <0.001 | <0.001 | * | 0.002 | 0.001 | 0.007 | 0.002 | 0.017 | 0.017 |
| 3T2-1 | 0.048 | 0.001 | 0.001 | 0.002 | 0.187 | 0.003 | 0.88 | 0.012 | 1.84 | 1.81 |
| 3T2-2 | 0.060 | 0.002 | 0.001 | 0.002 | 0.23 | 0.003 | 1.11 | 0.012 | 2.3 | 2.2 |
| 3T2-3 | 0.046 | 0.001 | 0.001 | 0.002 | 0.182 | 0.002 | 0.89 | 0.012 | 1.81 | 1.80 |
| 3T2-4 | 0.055 | 0.002 | 0.001 | 0.002 | 0.23 | 0.003 | 1.08 | 0.012 | 2.3 | 2.2 |
| 3T2-5 | 0.057 | 0.002 | 0.001 | 0.002 | 0.22 | 0.003 | 1.03 | 0.012 | 2.2 | 2.1 |
| 3T2-6 | 0.049 | 0.001 | 0.001 | 0.002 | 0.190 | 0.003 | 0.90 | 0.012 | 1.88 | 1.89 |

NS = north-south antenna.
EW = east-west antenna.
NEW = northern EW antenna element.
SEW = southern EW antenna element.
B = NS + EW antennas, standard phasing.
EX = extrapolated data.

* = data cannot be extrapolated.

# APPENDIX D

# UPLAND FLORA AND SOIL MICROFLORA STUDIES

## UPLAND FLORA AND SOIL MICROFLORA STUDIES

The major themes of the upland flora and microflora studies are the functional and structural aspects of organic material cycling. These studies investigate and characterize trees, herbaceous plants, and microflora (fungi and streptomycetes) populations. The electric and magnetic fields in the earth are considered important electromagnetic (EM) factors influencing soil biota and processes. The electric and magnetic fields in the air may influence any object extending above the surface of the earth. Because the electric field in the air can be greatly distorted and shielded by trees or plants on a study plot, special care was taken in characterizing the air electric field intensities to avoid such perturbations.

The treatment sites for these studies straddle the EW antenna and one of the grounding elements of the NRTF-Republic; the control site is located more than 28 miles from the nearest antenna element. The antenna treatment site and the control site each consist of three overstory tree plots (pole stands), three plots cleared and planted with red pine seedlings (plantations), and three plots set aside for the study of herbaceous plants (reserves). The ground treatment site consists of only three plots cleared and planted with red pine. No overstory tree plots or herbaceous reserves were established at the ground treatment site because the required buffer strips would have resulted in the biota being at too great a distance from the grounding elements for meaningful EM field exposure. Dropped foliage for decomposition studies are collected at the control site and at two sites in Houghton County.

IITRI field crews made ELF EM field measurements at 50 historic measurement points in 1990 within the two treatment sites, one control site, and three leaf sample collection points. The 1990 measurement points differed from those used in 1989 in that five new points (4T2-26 and 33 through 36) were added at the antenna site to establish a measurement profile across the pole stand and herbaceous reserve. Measurement dates for 1990 and previous years appear in Table D-1.

**TABLE D-1. EM FIELD MEASUREMENT DATES**
**Upland Flora and Soil Microflora Studies**

| Year | Measurement Dates | | |
|---|---|---|---|
| 1983 | Jun 7, 14 | | |
| 1984 | May 15, 21 | Aug 6, 9 | |
| 1985 | Jul 15, 17, 19 | | |
| 1986 | Oct 1, 2, 14 | | |
| 1987 | Sep 22, 23 | Oct 5, 7 | |
| 1988 | Sep 22 | Oct 5-7 | |
| 1989 | Sep 19 | Oct 11, 12 | |
| 1990 | Jun 27-30 | Aug 9 | Oct 1 |

**TABLE D-2. SITE NO. CROSS-REFERENCE**
**Upland Flora and Soil Microflora Studies**

| IITRI Site No. | Investigator's Site Name | Location Township | : | Range | : | Section(s) |
|---|---|---|---|---|---|---|
| 4T2 | Martell's Lake (Overhead): ML | T45N | : | R29W | : | 28 |
| 4T4 | Martell's Lake (Buried): EP | T45N | : | R29W | : | 28 |
| 4C1 | Paint Pond Road Control | T41N | : | R32W | : | 3 |
| 4S1 | Red Maple Leaf Collection | T55N | : | R35W | : | 21 |
| 4S2 | Oak Leaf Collection | T41N | : | R32W | : | 3 |
| 4S3 | Pine Needle Collection | T54N | : | R34W | : | 5 |

The positions of the study sites relative to the NRTF-Republic are shown on the composite map in Figure D-1. The site numbers listed on the map are those used by IITRI. Table D-2 provides a cross-reference of IITRI site numbers, investigator site names, and township, range, and section numbers for the sites. Details of measurement locations within sites are shown in Figures D-2 through D-6.

EM field measurements for 1990 and previous years are found in Tables D-3 through D-8. Tables D-3, D-4, and D-5 present 60 Hz data for the air electric field, earth electric field, and magnetic flux density, respectively. Tables D-6, D-7, and D-8 present 76 Hz data for these fields as well as the corresponding operating current of the NRTF-Republic for each year.

Ambient 60 Hz EM field intensities could not be measured at the treatment sites in 1989 or 1990 because of modulated signal operation of the NRTF-Republic during measurements at these sites. The 60 Hz EM field intensities measured at the control and leaf collection sites are consistent with values measured in previous years.

The 76 Hz EM field measurements in 1990 were made with 150 ampere antenna currents, the predominant operating current of the NRTF-Republic since 4 May 1989. The antenna currents at which measurements were made in each year are given in the column headings of Tables D-6 through D-8. The annual increases in field magnitudes reflect the level of antenna current at the time of measurement: 4 or 6 amperes in 1986, 15 amperes in 1987, 75 amperes in 1988, and 150 amperes in 1989 and 1990. The 1990 measurements are consistent with the 1989 measurements at the same current, and proportional to the 1986, 1987, and 1988 measurements made at lower currents.

Special efforts were made in 1990 to provide a detailed characterization of the earth electric field gradients at the treatment study sites. Discussion and presentation of this data, including plots of EM field profiles, earth electric field survey data, earth electric field contour maps, and fixed probe measurements of the earth electric field seasonal variations appear in Sections 4.2 and 4.3 of this report. Fixed probe measurement data and summary statistics for late June through December 1990 appear in Tables D-9 and D-10.

60297/190

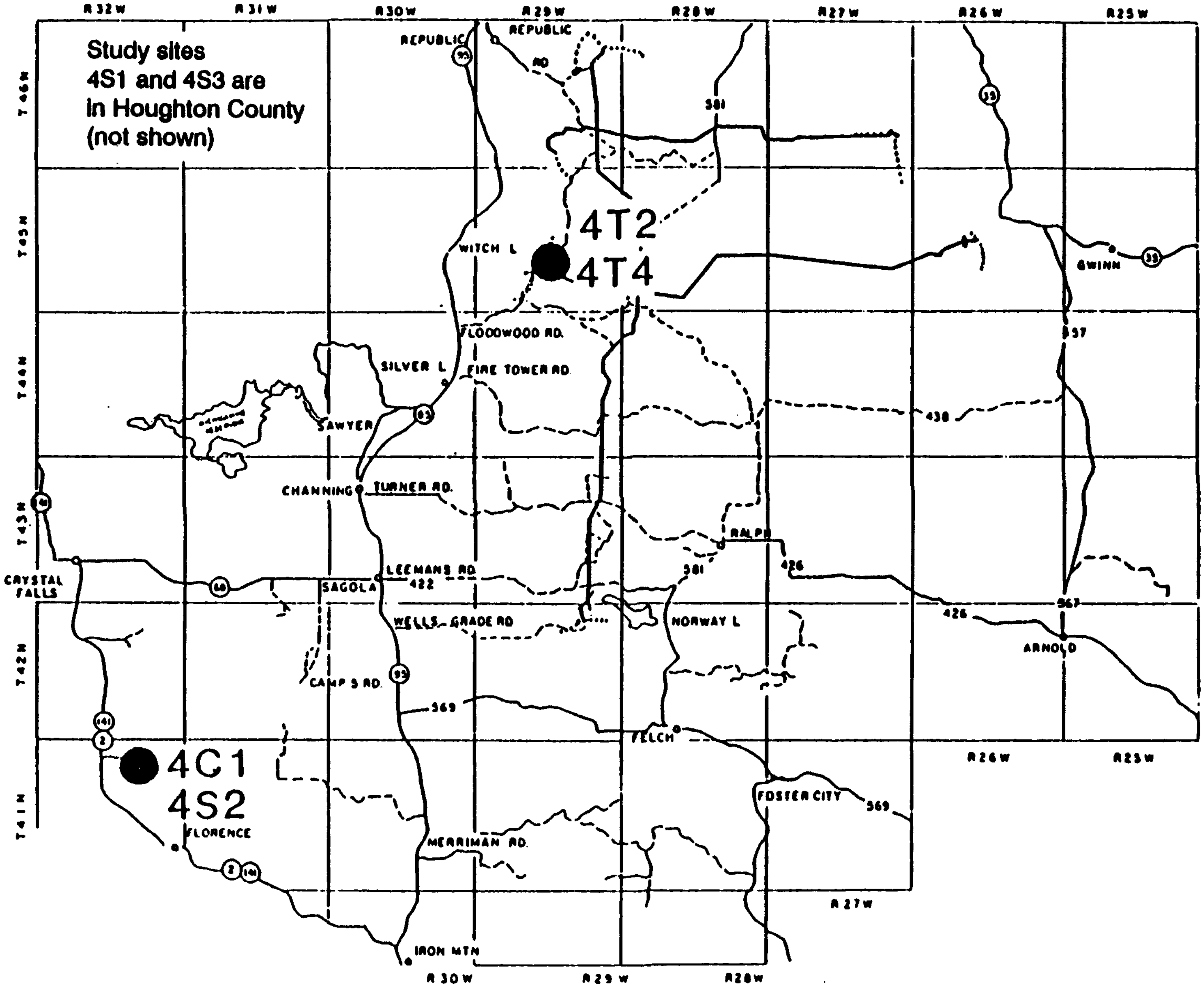



FIGURE D-1. POSITIONS OF UPLAND FLORA AND SOIL MICROFLORA STUDY SITES RELATIVE TO NRTF-REPUBLIC ANTENNA ELEMENTS.

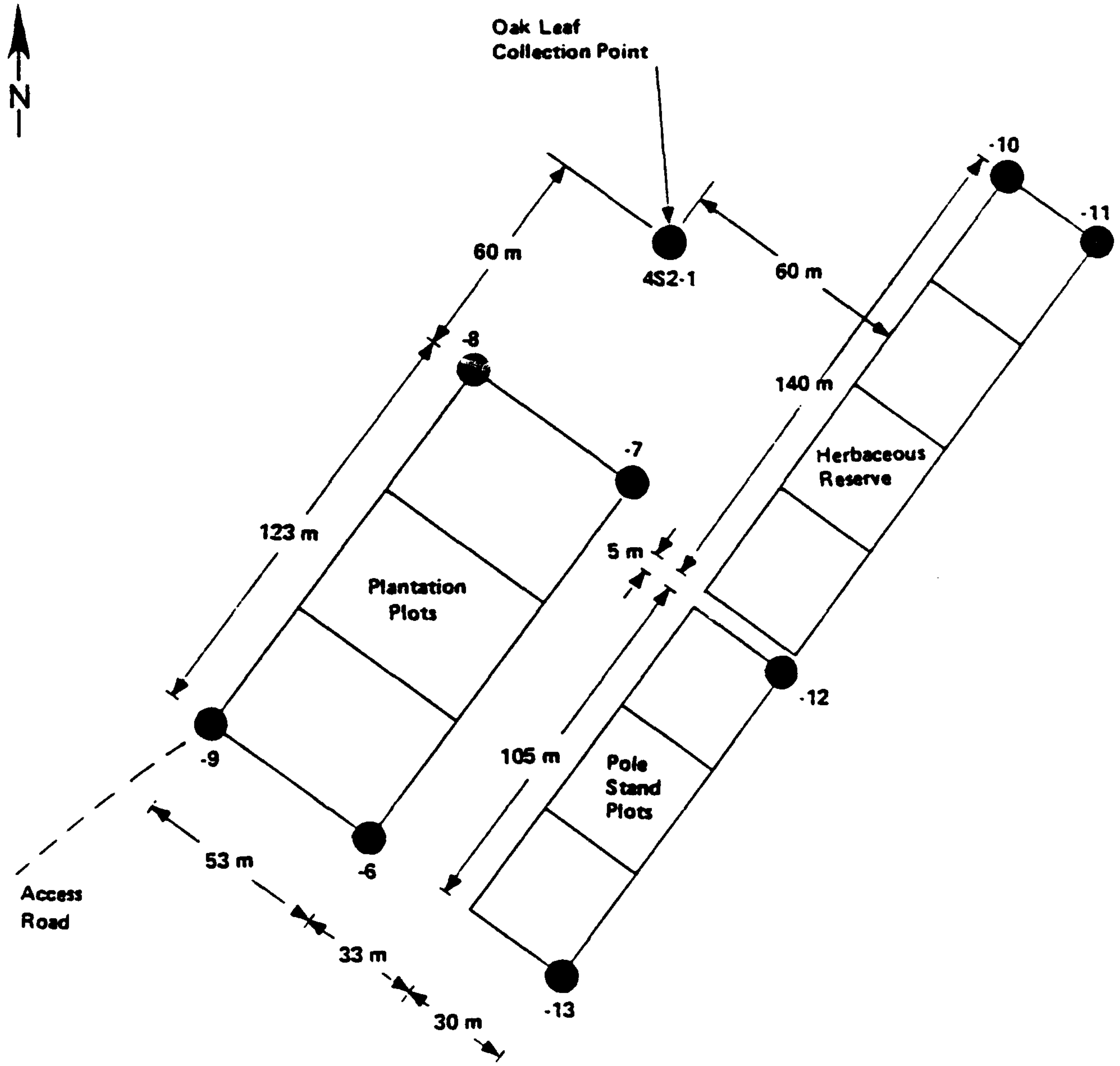



FIGURE D-2. MEASUREMENT POINTS AT PAINT POND ROAD CONTROL; 4C1-6 THROUGH 13, AND OAK LEAF COLLECTION SITE; 4S2-1.

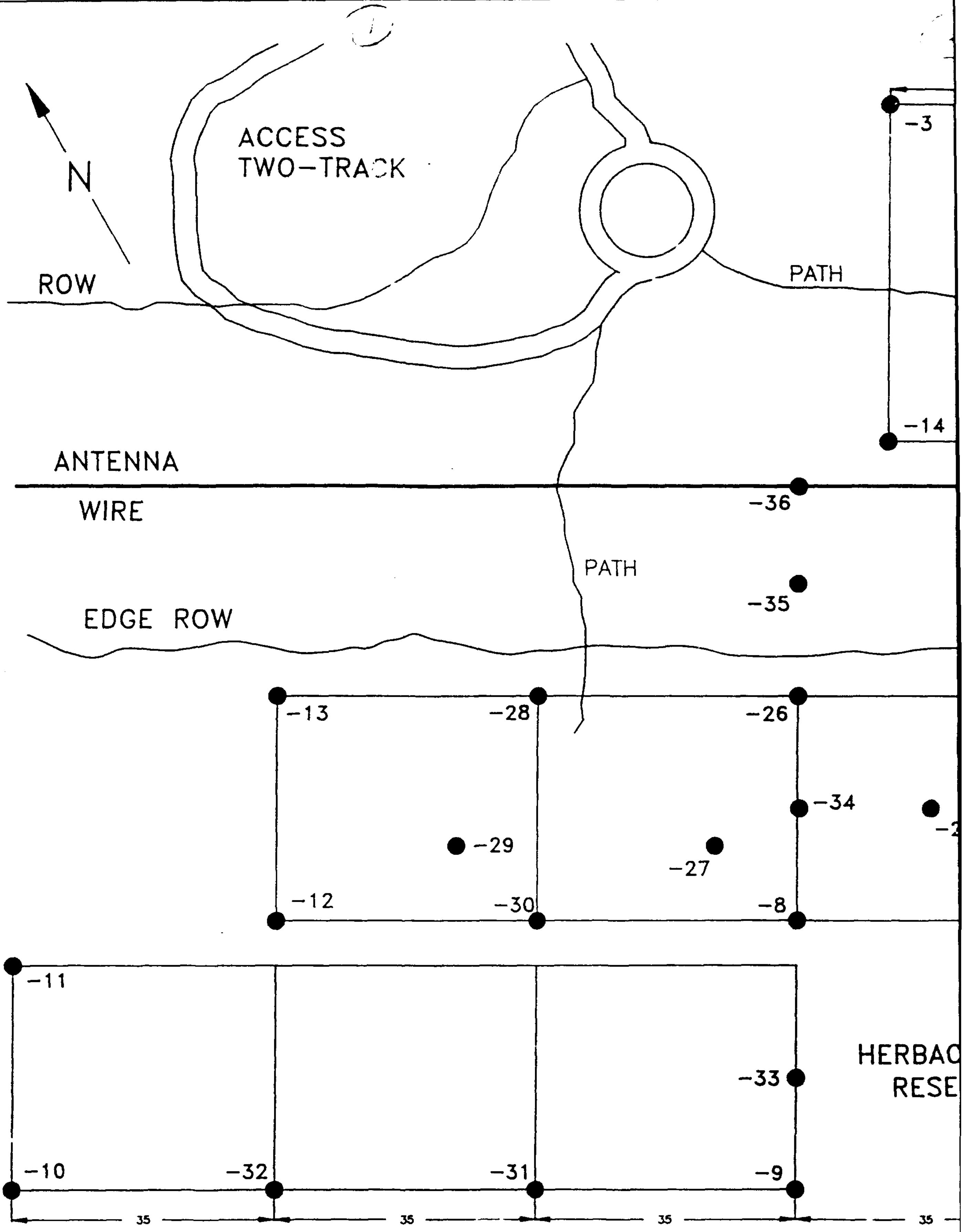



**FIGURE D-3. HISTORIC AND FIXED MEAS (OVERHEAD): ML; 4T2-3 TH**

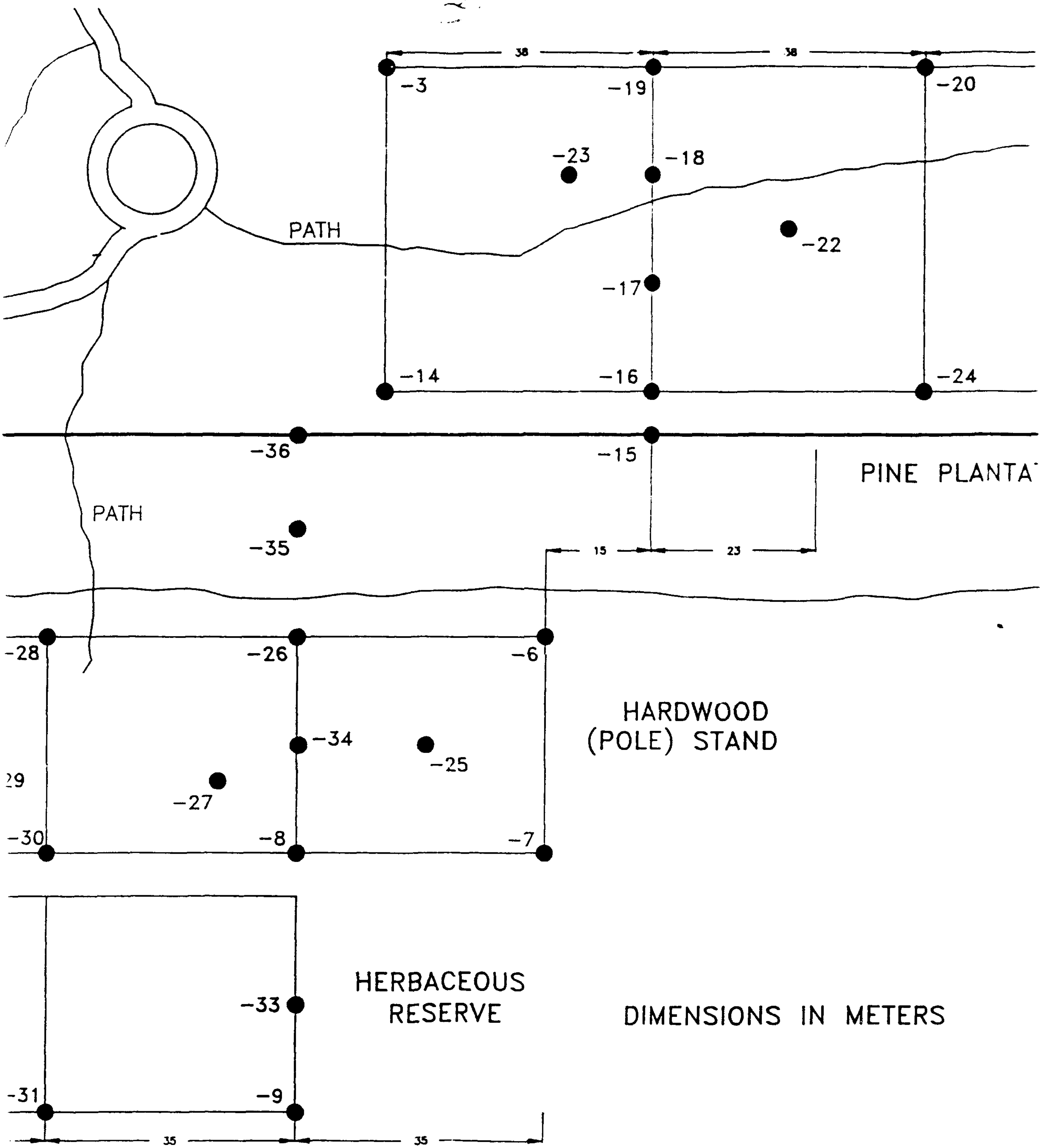
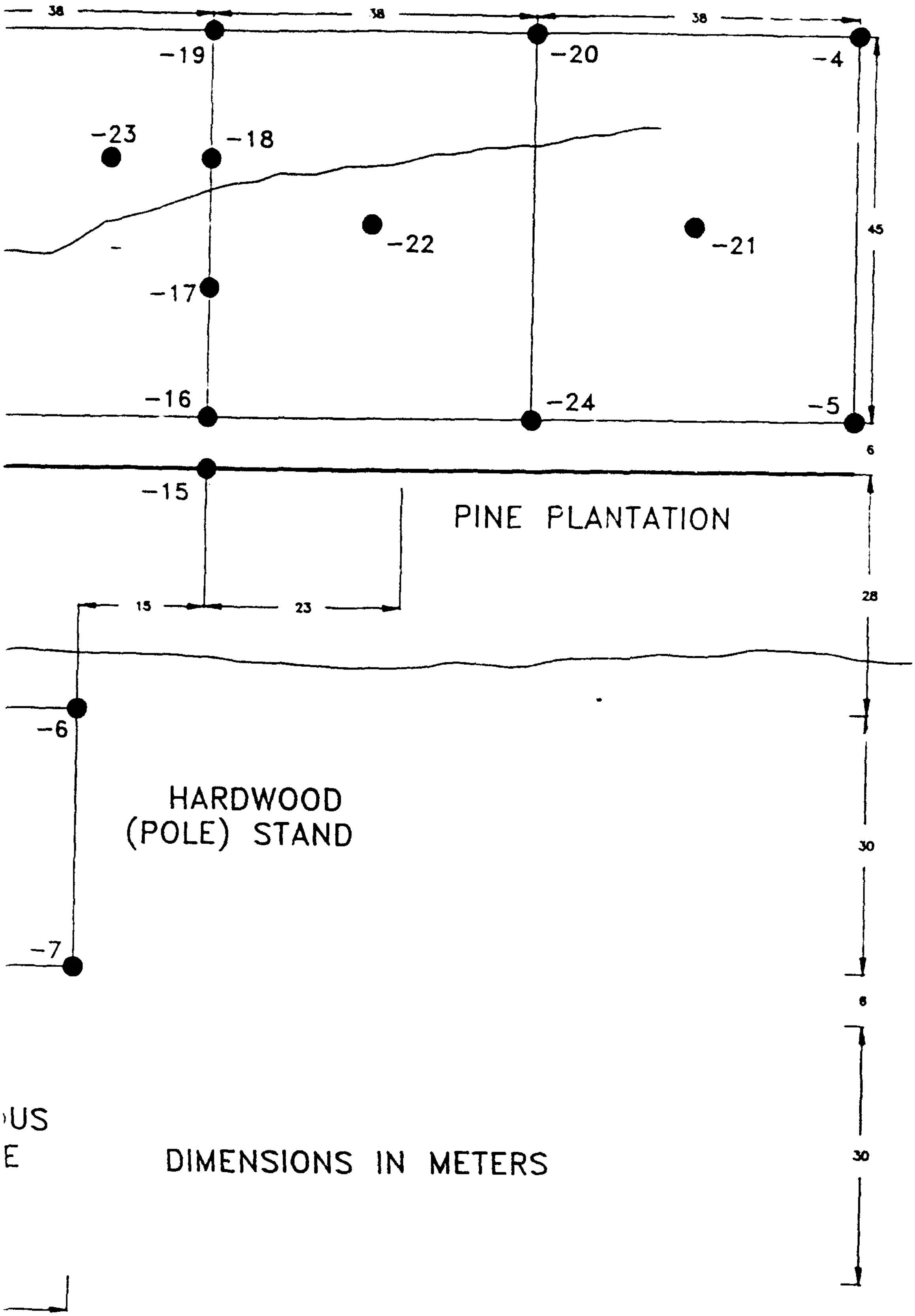



**FIGURE D-3. HISTORIC AND FIXED MEASUREMENT POINTS AT MARTELL'S LAKE (OVERHEAD): ML; 4T2-3 THROUGH 19.**




**:MENT POINTS AT MARTELL'S LAKE**
**JGH 19.**

IITRI E06628-3

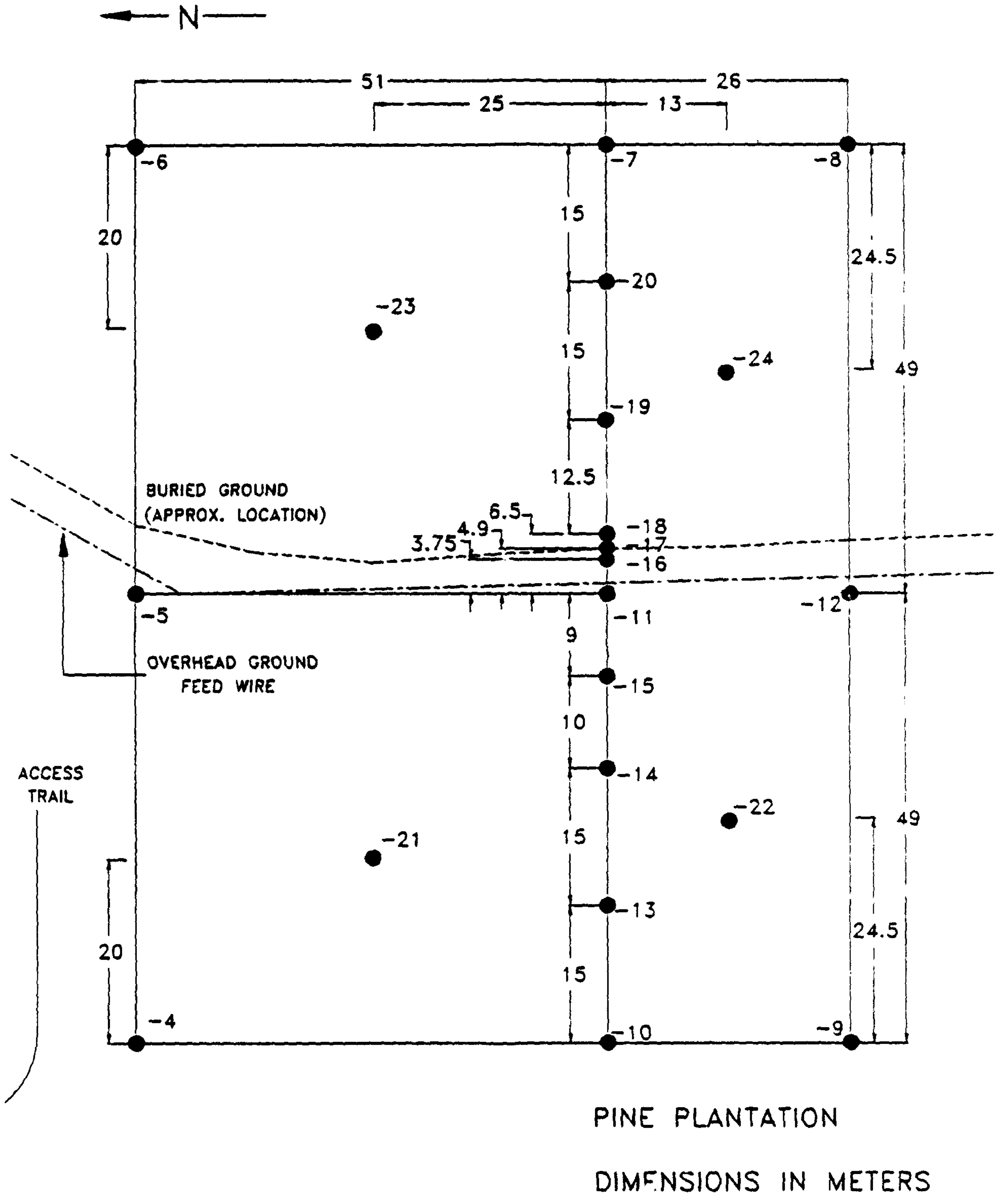



**FIGURE D-4. HISTORIC AND FIXED MEASUREMENT POINTS AT MARTELL'S LAKE (BURIED): EP; 4T4-4 THROUGH 24.**

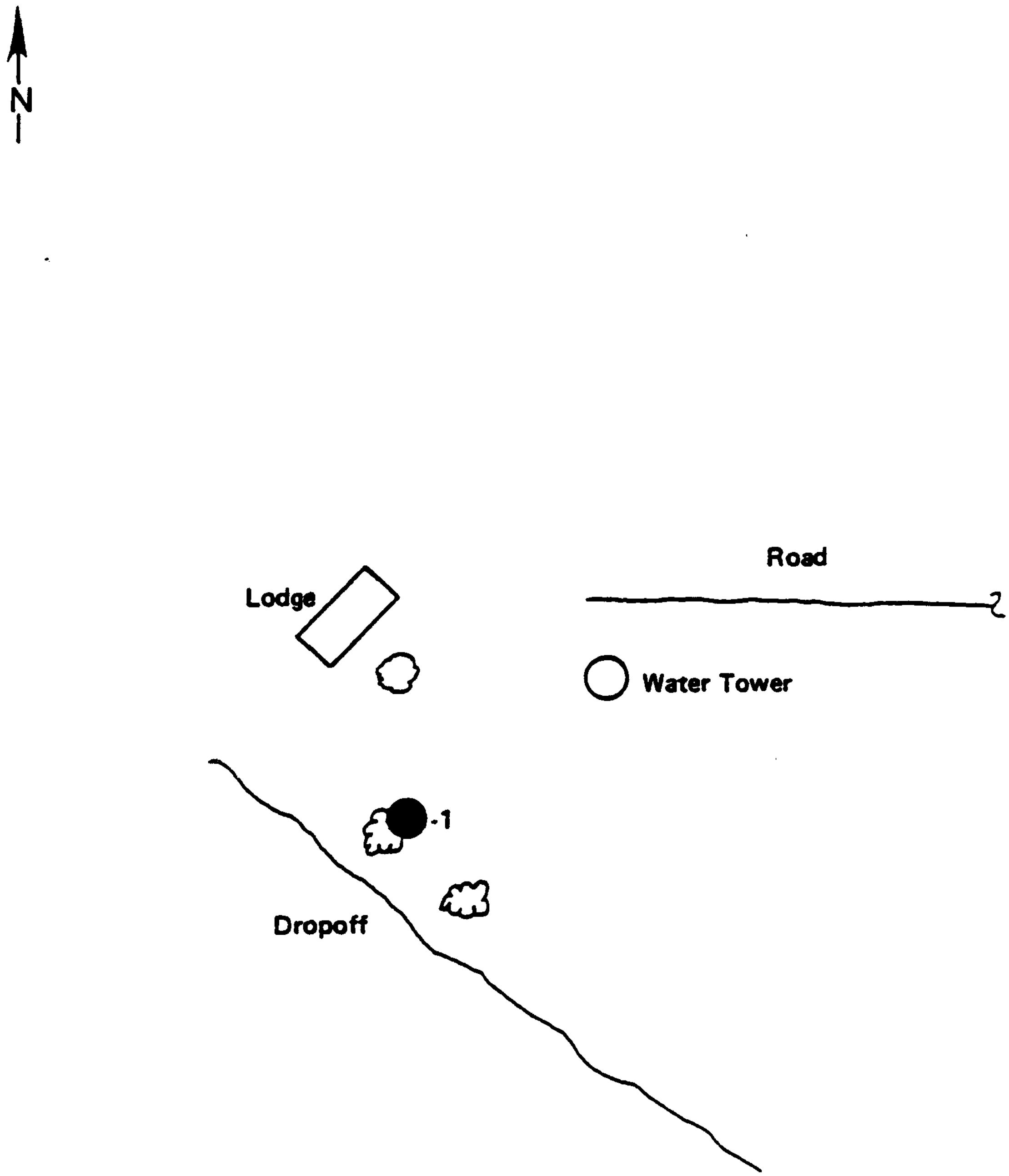



FIGURE D-5. MEASUREMENT POINT AT RED MAPLE LEAF COLLECTION SITE; 4S1-1.

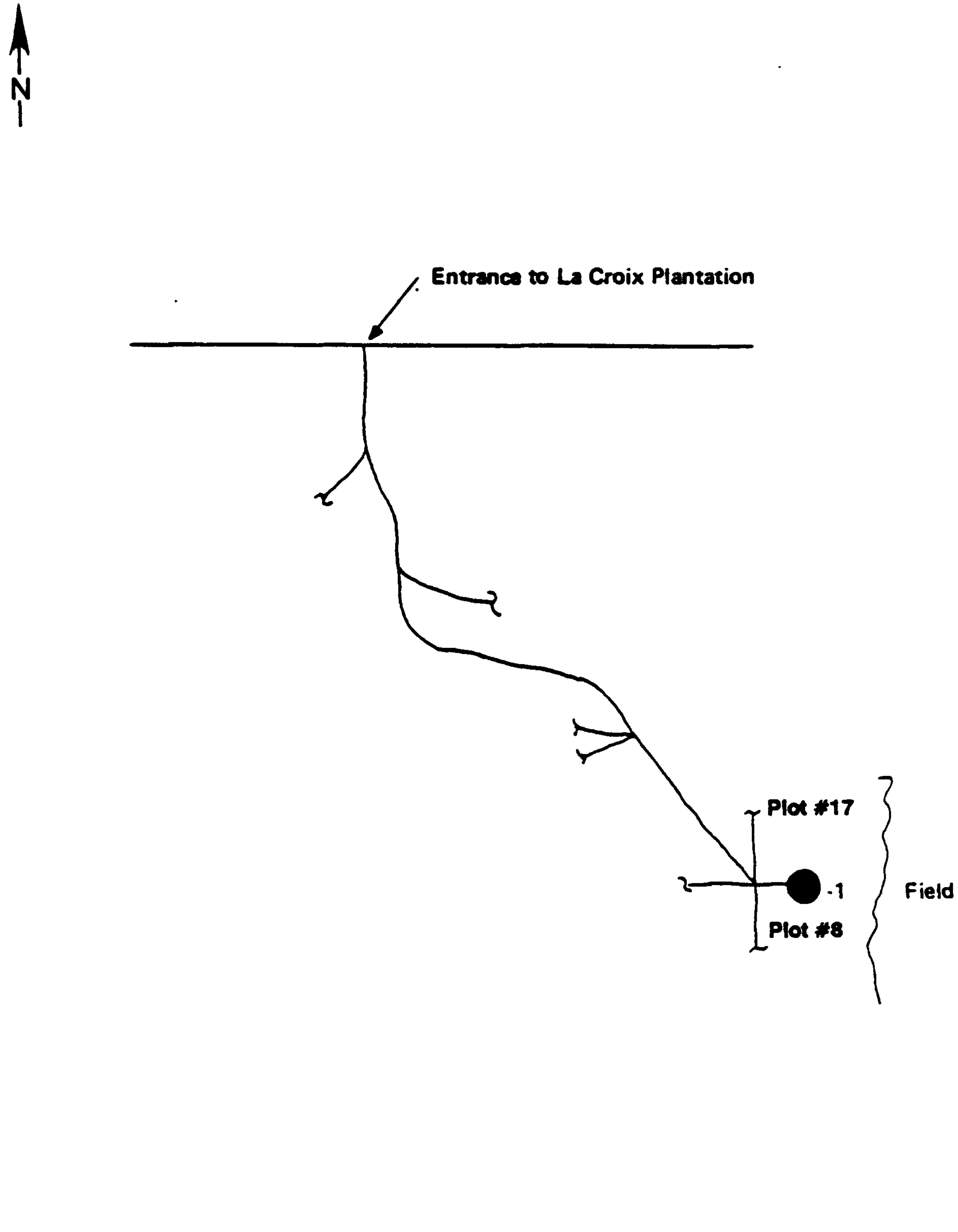



**FIGURE D-6. MEASUREMENT POINT AT THE PINE NEEDLE COLLECTION SITE; 4S3-1.**

TABLE D-3. 60 Hz AIR ELECTRIC FIELD INTENSITIES (V/m)
Upland Flora and Soil Microflora Studies
(page 1 of 2)

| Site No., Meas. Pt. | 1983[a] | 1984[a] | 1985[a] | 1986[b] | 1987[c] | 1988[c] | 1989[d] | 1990[d] |
|---|---|---|---|---|---|---|---|---|
| 4C1-6 | - | 0.003 | < | < | < | < | < | < |
| 4C1-7 | - | 0.006 | < | < | < | < | < | < |
| 4C1-8 | - | 0.004 | < | < | < | < | < | < |
| 4C1-9 | - | 0.002 | < | < | < | < | < | < |
| 4C1-10 | - | - | < | < | < | < | < | < |
| 4C1-11 | - | - | < | < | < | < | < | < |
| 4C1-12 | - | - | < | < | < | < | < | < |
| 4C1-13 | - | - | < | < | < | < | < | < |
| 4T2-3 | - | 0.001 | < | < | < | 0.002 | # | # |
| 4T2-4 | - | - | < | < | < | 0.001 | # | # |
| 4T2-5 | - | - | < | < | < | 0.011 | # | # |
| 4T2-6 | - | - | < | < | < | <0.001 | # | # |
| 4T2-7 | - | - | < | < | < | <0.001 | # | # |
| 4T2-8 | - | - | < | < | < | / | # | # |
| 4T2-9 | - | - | < | < | < | < | # | # |
| 4T2-10 | - | - | < | < | < | < | # | # |
| 4T2-11 | - | - | < | < | < | < | # | # |
| 4T2-12 | - | - | < | < | < | / | # | # |
| 4T2-13 | - | - | < | < | < | <0.001 | # | # |
| 4T2-14 | - | - | < | < | < | 0.011 | # | # |
| 4T2-15 | - | - | - | - | - | - | # | # |
| 4T2-16 | - | - | - | - | - | - | # | # |
| 4T2-17 | - | - | - | - | - | - | # | # |
| 4T2-18 | - | - | - | - | - | - | # | # |
| 4T2-19 | - | - | - | - | - | - | # | # |
| 4T2-26 | - | - | - | - | - | - | - | # |
| 4T2-33 | - | - | - | - | - | - | - | # |
| 4T2-34 | - | - | - | - | - | - | - | # |
| 4T2-35 | - | - | - | - | - | - | - | # |
| 4T2-36 | - | - | - | - | - | - | - | # |

a = antennas not constructed.
b = antennas off, grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 A current.

- = measurement point not established.
/ = measurement not taken.
# = measurement precluded by antenna operation.
< = measurement est. <0.001 V/m based on earth E-field.

TABLE D-3. 60 Hz AIR ELECTRIC FIELD INTENSITIES (V/m)
Upland Flora and Soil Microflora Studies
(page 2 of 2)

| Site No., Meas. Pt. | 1983[a] | 1984[a] | 1985[a] | 1986[b] | 1987[c] | 1988[c] | 1989[d] | 1990[d] |
|---|---|---|---|---|---|---|---|---|
| 4T4-4 | - | 0.003 | < | < | <0.001 | <0.001 | # | # |
| 4T4-5 | - | - | < | < | 0.006 | 0.003 | # | # |
| 4T4-6 | - | - | < | < | < | < | # | # |
| 4T4-7 | - | - | < | < | < | < | # | # |
| 4T4-8 | - | - | < | < | < | < | # | # |
| 4T4-9 | - | - | < | < | < | < | # | # |
| 4T4-10 | - | - | < | < | < | < | # | # |
| 4T4-11 | - | - | < | < | 0.010 | 0.009 | # | # |
| 4T4-12 | - | - | - | < | 0.005 | 0.007 | # | # |
| 4T4-13 | - | - | - | - | - | - | # | # |
| 4T4-14 | - | - | - | - | - | - | # | # |
| 4T4-15 | - | - | - | - | - | - | # | # |
| 4T4-16 | - | - | - | - | - | - | # | # |
| 4T4-17 | - | - | - | - | - | - | # | # |
| 4T4-18 | - | - | - | - | - | - | # | # |
| 4T4-19 | - | - | - | - | - | - | # | # |
| 4T4-20 | - | - | - | - | - | - | # | # |
| 4S1-1 | - | - | - | - | 0.013 | 0.033 | 0.011 | 0.017 |
| 4S2-1 | - | - | - | - | < | < | < | < |
| 4S3-1 | - | - | - | - | <0.001 | <0.001 | <0.001 | <0.001 |

a = antennas not constructed.
b = antennas off, grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 A current.

\- = measurement point not established.
/ = measurement not taken.
# = measurement precluded by antenna operation.
< = measurement est. <0.001 V/m based on earth E-field.

TABLE D-4. 60 Hz EARTH ELECTRIC FIELD INTENSITES (mV/m)
Upland Flora and Soil Microflora Studies
(page 1 of 2)

| Site No., Meas. Pt. | 1983[a] | 1984[a] | 1985[a] | 1986[b] | 1987[c] | 1988[c] | 1989[d] | 1990[d] |
|---|---|---|---|---|---|---|---|---|
| 4C1-6 | - | 0.022 | 0.016 | 0.005 | 0.043 | 0.023 | 0.016 | 0.024 |
| 4C1-7 | - | 0.143 | 0.123 | 0.077 | 0.178 | 0.118 | 0.030 | 0.039 |
| 4C1-8 | - | 0.104 | 0.117 | 0.077 | 0.131 | 0.078 | 0.018 | 0.063 |
| 4C1-9 | - | 0.011 | 0.019 | 0.024 | 0.034 | 0.032 | 0.023 | 0.023 |
| 4C1-10 | - | - | 0.090 | 0.068 | 0.118 | 0.106 | 0.054 | 0.041 |
| 4C1-11 | - | - | 0.160 | 0.107 | 0.132 | 0.146 | 0.066 | 0.068 |
| 4C1-12 | - | - | 0.104 | 0.101 | 0.075 | 0.093 | 0.042 | 0.042 |
| 4C1-13 | - | - | 0.040 | 0.030 | 0.046 | 0.065 | 0.025 | 0.039 |
| 4T2-3 | - | 0.51 | 0.39 | 0.194 | 0.27 | 0.28 | # | # |
| 4T2-4 | - | - | 0.27 | 0.24 | 0.30 | 0.25 | # | # |
| 4T2-5 | - | - | 0.43 | 0.32 | 0.20 | 0.20 | # | # |
| 4T2-6 | - | - | 0.66 | 0.46 | 0.192 | 0.22 | # | # |
| 4T2-7 | - | - | 0.42 | 0.52 | 0.197 | 0.28 | # | # |
| 4T2-8 | - | - | 0.47 | 0.190 | 0.22 | / | # | # |
| 4T2-9 | - | - | 0.49 | 0.31 | 0.183 | 0.25 | # | # |
| 4T2-10 | - | - | 0.44 | 0.32 | 0.155 | 0.166 | # | # |
| 4T2-11 | - | - | 0.51 | 0.40 | 0.31 | 0.43 | # | # |
| 4T2-12 | - | - | 0.47 | 0.38 | 0.24 | / | # | # |
| 4T2-13 | - | - | 0.76 | 0.31 | 0.31 | 0.25 | # | # |
| 4T2-14 | - | - | 0.61 | 0.29 | 0.35 | 0.21 | # | # |
| 4T2-15 | - | - | - | - | - | - | # | # |
| 4T2-16 | - | - | - | - | - | - | # | # |
| 4T2-17 | - | - | - | - | - | - | # | # |
| 4T2-18 | - | - | - | - | - | - | # | # |
| 4T2-19 | - | - | - | - | - | - | # | # |
| 4T2-26 | - | - | - | - | - | - | - | # |
| 4T2-33 | - | - | - | - | - | - | - | # |
| 4T2-34 | - | - | - | - | - | - | - | # |
| 4T2-35 | - | - | - | - | - | - | - | # |
| 4T2-36 | - | - | - | - | - | - | - | # |

a = antennas not constructed.
b = antennas off, grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 A current.

\- = measurement point not established.
/ = measurement not taken.
\# = measurement precluded by antenna operation.

TABLE D-4. 60 Hz EARTH ELECTRIC FIELD INTENSITIES (mV/m)
Upland Flora and Soil Microflora Studies
(page 2 of 2)

| Site No., Meas. Pt. | 1983[a] | 1984[a] | 1985[a] | 1986[b] | 1987[c] | 1988[c] | 1989[d] | 1990[d] |
|---|---|---|---|---|---|---|---|---|
| 4T4-4 | - | 0.72 | 0.42 | 0.185 | 0.56 | 0.079 | # | # |
| 4T4-5 | - | - | 0.58 | 0.58 | 4.3 | 1.12 | # | # |
| 4T4-6 | - | - | 0.22 | 0.16 | 0.61 | 0.188 | # | # |
| 4T4-7 | - | - | 0.44 | 0.29 | 0.64 | 0.22 | # | # |
| 4T4-8 | - | - | 0.42 | 0.193 | 0.40 | 0.23 | # | # |
| 4T4-9 | - | - | 0.50 | 0.21 | 0.27 | 0.073 | # | # |
| 4T4-10 | - | - | 0.42 | 0.22 | 0.29 | 0.063 | # | # |
| 4T4-11 | - | - | 0.40 | 0.60 | 2.7 | 1.27 | # | # |
| 4T4-12 | - | - | - | 0.75 | 3.4 | 1.35 | # | # |
| 4T4-13 | - | - | - | - | - | - | # | # |
| 4T4-14 | - | - | - | - | - | - | # | # |
| 4T4-15 | - | - | - | - | - | - | # | # |
| 4T4-16 | - | - | - | - | - | - | # | # |
| 4T4-17 | - | - | - | - | - | - | # | # |
| 4T4-18 | - | - | - | - | - | - | # | # |
| 4T4-19 | - | - | - | - | - | - | # | # |
| 4T4-20 | - | - | - | - | - | - | # | # |
| 4S1-1 | - | - | - | - | 8.5 | 12.2 | 11.6 | 15.7 |
| 4S2-1 | - | - | - | - | 0.155 | 0.109 | 0.032 | 0.068 |
| 4S3-1 | - | - | - | - | 0.65 | 1.73 | 0.73 | 0.87 |

a = antennas not constructed.
b = antennas grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 A current.

\- = measurement point not established.
/ = measurement not taken.
# = measurement precluded by antenna operation.

**TABLE D-5. 60 Hz MAGNETIC FLUX DENSITIES (mG)**
**Upland Flora and Soil Microflora Studies**
**(page 1 of 2)**

| Site No., Meas. Pt. | 1983[a] | 1984[a] | 1985[a] | 1986[b] | 1987[c] | 1988[c] | 1989[d] | 1990[d] |
|---|---|---|---|---|---|---|---|---|
| 4C1-6 | - | 0.003 | 0.003 | 0.003 | 0.002 | 0.003 | 0.002 | 0.002 |
| 4C1-7 | - | 0.003 | 0.002 | 0.001 | 0.003 | 0.002 | 0.001 | 0.002 |
| 4C1-8 | - | 0.003 | 0.003 | 0.002 | 0.003 | 0.002 | 0.001 | 0.002 |
| 4C1-9 | - | 0.003 | 0.003 | 0.002 | 0.001 | 0.002 | 0.002 | 0.002 |
| 4C1-10 | - | - | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 |
| 4C1-11 | - | - | 0.002 | 0.002 | 0.002 | 0.002 | 0.001 | 0.002 |
| 4C1-12 | - | - | 0.002 | 0.003 | 0.001 | 0.002 | 0.001 | 0.002 |
| 4C1-13 | - | - | 0.002 | 0.003 | 0.001 | 0.003 | 0.002 | 0.002 |
| 4T2-3 | - | 0.002 | 0.001 | 0.001 | 0.003 | 0.005 | # | # |
| 4T2-4 | - | - | 0.001 | 0.001 | 0.003 | 0.006 | # | # |
| 4T2-5 | - | - | 0.001 | 0.007 | 0.017 | 0.030 | # | # |
| 4T2-6 | - | - | 0.001 | 0.006 | 0.006 | 0.014 | # | # |
| 4T2-7 | - | - | 0.001 | 0.004 | 0.004 | 0.007 | # | # |
| 4T2-8 | - | - | 0.001 | 0.002 | 0.004 | / | # | # |
| 4T2-9 | - | - | 0.001 | 0.003 | 0.003 | 0.005 | # | # |
| 4T2-10 | - | - | 0.001 | 0.003 | 0.003 | 0.005 | # | # |
| 4T2-11 | - | - | 0.001 | 0.004 | 0.005 | 0.007 | # | # |
| 4T2-12 | - | - | 0.002 | 0.004 | 0.005 | / | # | # |
| 4T2-13 | - | - | 0.001 | 0.005 | 0.008 | 0.013 | # | # |
| 4T2-14 | - | - | 0.002 | 0.011 | 0.018 | 0.029 | # | # |
| 4T2-15 | - | - | - | - | - | - | # | # |
| 4T2-16 | - | - | - | - | - | - | # | # |
| 4T2-17 | - | - | - | - | - | - | # | # |
| 4T2-18 | - | - | - | - | - | - | # | # |
| 4T2-19 | - | - | - | - | - | - | # | # |
| 4T2-26 | - | - | - | - | - | - | - | # |
| 4T2-33 | - | - | - | - | - | - | - | # |
| 4T2-34 | - | - | - | - | - | - | - | # |
| 4T2-35 | - | - | - | - | - | - | - | # |
| 4T2-36 | - | - | - | - | - | - | - | # |

a = antennas not constructed.
b = antennas grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 A current.

\- = measurement point not established.
/ = measurement not taken.
\# = measurement precluded by antenna operation.

TABLE D-5. 60 Hz MAGNETIC FLUX DENSITIES (mG)
Upland Flora and Soil Microflora Studies
(page 2 of 2)

| Site No., Meas. Pt. | 1983[a] | 1984[a] | 1985[a] | 1986[b] | 1987[c] | 1988[c] | 1989[d] | 1990[d] |
|---|---|---|---|---|---|---|---|---|
| 4T4-4 | - | 0.004 | 0.002 | 0.001 | 0.003 | 0.003 | # | # |
| 4T4-5 | - | - | 0.002 | 0.006 | 0.010 | 0.017 | # | # |
| 4T4-6 | - | - | 0.002 | 0.001 | 0.004 | 0.007 | # | # |
| 4T4-7 | - | - | 0.001 | 0.001 | 0.004 | 0.005 | # | # |
| 4T4-8 | - | - | 0.002 | 0.001 | 0.004 | 0.005 | # | # |
| 4T4-9 | - | - | 0.002 | 0.001 | 0.002 | 0.003 | # | # |
| 4T4-10 | - | - | 0.001 | 0.001 | 0.002 | 0.002 | # | # |
| 4T4-11 | - | - | 0.002 | 0.002 | 0.012 | 0.019 | # | # |
| 4T4-12 | - | - | - | 0.002 | 0.010 | 0.016 | # | # |
| 4T4-13 | - | - | - | - | - | - | # | # |
| 4T4-14 | - | - | - | - | - | - | # | # |
| 4T4-15 | - | - | - | - | - | - | # | # |
| 4T4-16 | - | - | - | - | - | - | # | # |
| 4T4-17 | - | - | - | - | - | - | # | # |
| 4T4-18 | - | - | - | - | - | - | # | # |
| 4T4-19 | - | - | - | - | - | - | # | # |
| 4T4-20 | - | - | - | - | - | - | # | # |
| 4S1-1 | - | - | - | - | 0.035 | 0.043 | 0.052 | 0.052 |
| 4S2-1 | - | - | - | - | 0.003 | 0.002 | 0.002 | 0.001 |
| 4S3-1 | - | - | - | - | 0.036 | 0.095 | 0.028 | 0.030 |

a = antennas not constructed.
b = antennas grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 A current.

\- = measurement point not established.
/ = measurement not taken.
# = measurement precluded by antenna operation.

TABLE D-6. 76 Hz AIR ELECTRIC FIELD INTENSITIES (V/m)
Upland Flora and Soil Microflora Studies
(page 1 of 2)

| SITE NO., MEAS.PT. | 1986 NS 4 amps | 1986 NEW 6 amps | 1986 SEW 6 amps | 1986 SEW 10 amps (EX) | 1987 NS 15 amps | 1987 EW 15 amps | 1988 NS 75 amps | 1988 EW 75 amps | 1989 B 150 amps | 1990 B 150 amps |
|---|---|---|---|---|---|---|---|---|---|---|
| 4C1-6 | < | < | < | * | < | < | < | < | < | < |
| 4C1-7 | < | < | < | * | < | < | < | < | < | < |
| 4C1-8 | < | < | < | * | < | < | < | < | < | < |
| 4C1-9 | < | < | < | * | < | < | < | < | < | < |
| 4C1-10 | < | < | < | * | < | < | < | < | < | < |
| 4C1-11 | < | < | < | * | < | < | < | < | < | < |
| 4C1-12 | < | < | < | * | < | < | < | < | < | < |
| 4C1-13 | < | < | < | * | < | < | < | < | < | < |
| 4T2-3 | < | < | 0.004 | 0.007 | 0.002 | 0.014 | 0.006 | 0.125 | 0.142 | 0.110 |
| 4T2-4 | < | < | 0.005 | 0.008 | 0.001 | 0.014 | 0.017 | 0.113 | 0.149 | 0.122 |
| 4T2-5 | 0.018 | < | 0.092 | 0.153 | 0.003 | 0.23 | 0.033 | 2.6 | 1.31 | 1.16 |
| 4T2-6 | < | < | 0.005 | 0.008 | 0.003 | 0.013 | 0.014 | 0.142 | 0.138 | 0.148 |
| 4T2-7 | < | < | 0.007 | 0.012 | 0.001 | 0.018 | 0.020 | 0.165 | 0.173 | 0.177 |
| 4T2-8 | < | < | 0.004 | 0.007 | 0.002 | 0.012 | / | / | 0.124 | 0.112 |
| 4T2-9 | < | < | 0.005 | 0.008 | 0.002 | 0.010 | 0.019 | 0.137 | 0.116 | 0.119 |
| 4T2-10 | < | < | 0.004 | 0.007 | 0.002 | 0.011 | 0.020 | 0.112 | 0.113 | 0.076 |
| 4T2-11 | < | < | 0.003 | 0.005 | 0.002 | 0.012 | 0.010 | 0.130 | 0.22 | 0.180 |
| 4T2-12 | < | < | 0.002 | 0.003 | 0.002 | 0.014 | / | / | 0.095 | 0.096 |
| 4T2-13 | < | < | 0.005 | 0.008 | 0.002 | 0.012 | 0.010 | 0.121 | 0.125 | 0.130 |
| 4T2-14 | 0.030 | < | 0.155 | 0.26 | 0.003 | 0.186 | 0.026 | 2.5 | 1.66 | 1.94 |
| 4T2-15 | - | - | - | - | - | - | - | - | 2.3 | 1.67 |
| 4T2-16 | - | - | - | - | - | - | - | - | 1.92 | 1.84 |
| 4T2-17 | - | - | - | - | - | - | - | - | 0.69 | 0.59 |
| 4T2-18 | - | - | - | - | - | - | - | - | 0.28 | 0.21 |
| 4T2-19 | - | - | - | - | - | - | - | - | 0.107 | 0.105 |
| 4T2-26 | - | - | - | - | - | - | - | - | - | 0.182 |
| 4T2-33 | - | - | - | - | - | - | - | - | - | 0.141 |
| 4T2-34 | - | - | - | - | - | - | - | - | - | 0.144 |
| 4T2-35 | - | - | - | - | - | - | - | - | - | 0.24 |
| 4T4-36 | - | - | - | - | - | - | - | - | - | 4.7 |

NS = north-south antenna.
EW = east-west antenna.
NEW = northern EW antenna element.
SEW = southern EW antenna element.
B = NS + EW antennas, standard phasing.
EX = extrapolated data.

- = measurement point not established.
/ = measurement not taken.
< = measurement est. <0.001 based on earth E-field.
* = data cannot be extrapolated.

TABLE D-6. 76 Hz AIR ELECTRIC FIELD INTENSITIES (V/m)
Upland Flora and Soil Microflora Studies
(page 2 of 2)

| | 1986 | | | | 1987 | | 1988 | | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|---|
| SITE NO., MEAS.PT. | NS 4 amps | NEW 6 amps | SEW 6 amps | SEW 10 amps (EX) | NS 15 amps | EW 15 amps | NS 75 amps | EW 75 amps | B 150 amps | B 150 amps |
| 4T4-4 | < | < | 0.006 | 0.010 | 0.002 | 0.005 | 0.008 | 0.028 | 0.067 | 0.058 |
| 4T4-5 | 0.033 | 0.008 | 0.20 | 0.33 | 0.019 | 0.27 | 0.089 | 1.31 | 4.8 | 3.8 |
| 4T4-6 | 0.005 | < | 0.023 | 0.038 | 0.002 | 0.021 | 0.011 | 0.064 | 0.175 | 0.117 |
| 4T4-7 | < | < | 0.006 | 0.010 | 0.002 | 0.015 | 0.008 | 0.090 | 0.133 | 0.129 |
| 4T4-8 | < | < | 0.008 | 0.013 | 0.002 | 0.016 | 0.007 | 0.083 | 0.145 | 0.145 |
| 4T4-9 | < | < | 0.009 | 0.015 | 0.001 | 0.008 | 0.009 | 0.047 | 0.095 | 0.072 |
| 4T4-10 | < | < | 0.007 | 0.012 | 0.001 | 0.001 | 0.011 | 0.057 | 0.112 | 0.085 |
| 4T4-11 | < | 0.005 | 0.38 | 0.63 | 0.025 | 0.43 | 0.20 | 4.4 | 5.0 | 4.6 |
| 4T4-12 | 0.055 | 0.005 | 0.43 | 0.72 | 0.017 | 0.30 | 0.150 | 2.1 | 4.5 | 3.8 |
| 4T4-13 | - | - | - | - | - | - | - | - | 0.26 | 0.21 |
| 4T4-14 | - | - | - | - | - | - | - | - | 0.88 | 0.84 |
| 4T4-15 | - | - | - | - | - | - | - | - | 2.7 | 2.6 |
| 4T4-16 | - | - | - | - | - | - | - | - | 5.9 | 5.4 |
| 4T4-17 | - | - | - | - | - | - | - | - | 4.5 | 4.3 |
| 4T4-18 | - | - | - | - | - | - | - | - | 4.8 | 3.8 |
| 4T4-19 | - | - | - | - | - | - | - | - | 1.16 | 0.96 |
| 4T4-20 | - | - | - | - | - | - | - | - | 0.32 | 0.183 |
| 4S1-1 | - | - | - | - | < | < | < | < | < | < |
| 4S2-1 | - | - | - | - | < | < | < | < | < | < |
| 4S3-1 | - | - | - | - | < | < | < | < | < | < |

NS = north-south antenna.
EW = east-west antenna.
NEW = northern EW antenna element.
SEW = southern EW antenna element.
B = NS + EW antennas, standard phasing.
EX = extrapolated data.

- = measurement point not established.
/ = measurement not taken.
< = measurement est. <0.001 V/m based on earth E-field.
* = data cannot be extrapolated.

TABLE D-7. 76 Hz EARTH ELECTRIC FIELD INTENSITIES (mV/m)
Upland Flora and Soil Microflora Studies
(page 1 of 2)

| SITE NO., MEAS.PT. | 1986 NS 4 amps | 1986 NEW 6 amps | 1986 SEW 6 amps | 1986 SEW 10 amps (EX) | 1987 NS 15 amps | 1987 EW 15 amps | 1988 NS 75 amps | 1988 EW 75 amps | 1989 B 150 amps | 1990 B 150 amps |
|---|---|---|---|---|---|---|---|---|---|---|
| 4C1-6 | <0.001 | <0.001 | <0.001 | * | 0.002 | 0.002 | 0.007 | 0.005 | 0.030 | 0.028 |
| 4C1-7 | <0.001 | <0.001 | <0.001 | * | 0.005 | 0.006 | 0.024 | 0.023 | 0.091 | 0.085 |
| 4C1-8 | <0.001 | <0.001 | <0.001 | * | 0.004 | 0.004 | 0.017 | 0.016 | 0.076 | 0.067 |
| 4C1-9 | <0.001 | <0.001 | <0.001 | * | 0.002 | 0.002 | 0.007 | 0.006 | 0.030 | 0.022 |
| 4C1-10 | <0.001 | <0.001 | <0.001 | * | 0.005 | 0.004 | 0.026 | 0.023 | 0.087 | 0.079 |
| 4C1-11 | <0.001 | <0.001 | <0.001 | * | 0.006 | 0.005 | 0.028 | 0.028 | 0.113 | 0.103 |
| 4C1-12 | <0.001 | <0.001 | <0.001 | * | 0.004 | 0.003 | 0.016 | 0.016 | 0.068 | 0.072 |
| 4C1-13 | <0.001 | <0.001 | <0.001 | * | 0.002 | 0.002 | 0.012 | 0.011 | 0.051 | 0.044 |
| 4T2-3 | 1.31 | 0.22 | 6.3 | 10.5 | 1.36 | 15.2 | 7.7 | 76 | 131 | 140 |
| 4T2-4 | 1.05 | 0.22 | 5.0 | 8.3 | 1.70 | 10.7 | 6.2 | 68 | 135 | 129 |
| 4T2-5 | 1.18 | 0.24 | 5.3 | 8.8 | 1.46 | 12.7 | 8.2 | 62 | 86 | 105 |
| 4T2-6 | 1.11 | 0.27 | 4.4 | 7.3 | 2.2 | 12.4 | 10.4 | 56 | 105 | 101 |
| 4T2-7 | 1.13 | 0.23 | 5.3 | 8.8 | 1.31 | 9.7 | 8.8 | 71 | 90 | 89 |
| 4T2-8 | 1.32 | 0.25 | 5.7 | 9.5 | 1.81 | 15.8 | / | / | 141 | 135 |
| 4T2-9 | 1.17 | 0.21 | 5.1 | 8.5 | 1.46 | 13.7 | 7.1 | 63 | 119 | 125 |
| 4T2-10 | 0.97 | 0.22 | 4.1 | 6.8 | 1.84 | 10.5 | 8.1 | 50 | 96 | 91 |
| 4T2-11 | 1.14 | 0.21 | 5.0 | 8.3 | 2.2 | 10.7 | 9.6 | 122 | 182 | 170 |
| 4T2-12 | 1.06 | 0.21 | 4.3 | 7.2 | 1.93 | 13.5 | / | / | 99 | 114 |
| 4T2-13 | 1.12 | 0.64 | 5.4 | 9.0 | 1.74 | 14.9 | 8.2 | 71 | 138 | 144 |
| 4T2-14 | 1.07 | 0.175 | 5.1 | 8.5 | 1.66 | 14.3 | 6.6 | 56 | 124 | 121 |
| 4T2-15 | - | - | - | - | - | - | - | - | 73 | 82 |
| 4T2-16 | - | - | - | - | - | - | - | - | 88 | 86 |
| 4T2-17 | - | - | - | - | - | - | - | - | 104 | 105 |
| 4T2-18 | - | - | - | - | - | - | - | - | 95 | 99 |
| 4T2-19 | - | - | - | - | - | - | - | - | 107 | 107 |
| 4T2-26 | - | - | - | - | - | - | - | - | - | 210 |
| 4T2-33 | - | - | - | - | - | - | - | - | - | 113 |
| 4T2-34 | - | - | - | - | - | - | - | - | - | 152 |
| 4T2-35 | - | - | - | - | - | - | - | - | - | 136 |
| 4T2-36 | - | - | - | - | - | - | - | - | - | 155 |

NS = north-south antenna.
EW = east-west antenna.
NEW = northern EW antenna element.
SEW = southern EW antenna element.
B = NS + EW antennas, standard phasing.
EX = extrapolated data.

- = measurement point not established.
/ = measurement not taken.
* = data cannot be extrapolated.

TABLE D-7. 76 Hz EARTH ELECTRIC FIELD INTENSITIES (mV/m)
Upland Flora and Soil Microflora Studies
(page 2 of 2)

| SITE NO., MEAS.PT. | 1986 NS 4 amps | 1986 NEW 6 amps | 1986 SEW 6 amps | 1986 SEW 10 amps (EX) | 1987 NS 15 amps | 1987 EW 15 amps | 1988 NS 75 amps | 1988 EW 75 amps | 1989 B 150 amps | 1990 B 150 amps |
|---|---|---|---|---|---|---|---|---|---|---|
| 4T4-4 | 0.33 | 0.181 | 1.46 | 2.4 | 1.63 | 3.7 | 7.2 | 16.5 | 42 | 31 |
| 4T4-5 | 13.8 | 2.0 | 81. | 135. | 14.0 | 194. | 68 | 910 | 2100 | 1670 |
| 4T4-6 | 1.22 | 0.22 | 6.2 | 10.3 | 2.2 | 12.9 | 10.3 | 62 | 140 | 117 |
| 4T4-7 | 0.94 | 0.175 | 5.5 | 9.2 | 2.0 | 14.1 | 9.1 | 62 | 119 | 135 |
| 4T4-8 | 0.91 | 0.188 | 5.3 | 8.8 | 1.36 | 10.7 | 6.8 | 65 | 106 | 113 |
| 4T4-9 | 0.29 | 0.130 | 1.32 | 2.2 | 1.08 | 3.0 | 7.5 | 18.1 | 47 | 42 |
| 4T4-10 | 0.29 | 0.169 | 1.63 | 2.7 | 1.35 | 3.9 | 5.1 | 16.0 | 39 | 43 |
| 4T4-11 | 0.59 | 1.82 | 89. | 148. | 10.7 | 178. | 50 | 850 | 1870 | 1890 |
| 4T4-12 | 21. | 2.2 | 118. | 197. | 13.8 | 260. | 40 | 760 | 1950 | 1600 |
| 4T4-13 | - | - | - | - | - | - | - | - | 64 | 56 |
| 4T4-14 | - | - | - | - | - | - | - | - | 220 | 200 |
| 4T4-15 | - | - | - | - | - | - | - | - | 760 | 760 |
| 4T4-16 | - | - | - | - | - | - | - | - | 3000 | 3800 |
| 4T4-17 | - | - | - | - | - | - | - | - | 130 | 30 |
| 4T4-18 | - | - | - | - | - | - | - | - | 3200 | 3600 |
| 4T4-19 | - | - | - | - | - | - | - | - | 750 | 880 |
| 4T4-20 | - | - | - | - | - | - | - | - | 200 | 163 |
| 4S1-1 | - | - | - | - | <0.001 | <0.001 | <0.001 | <0.001 | / | / |
| 4S2-1 | - | - | - | - | 0.005 | 0.005 | 0.026 | 0.026 | 0.126 | 0.103 |
| 4S3-1 | - | - | - | - | <0.001 | <0.001 | <0.001 | <0.001 | / | / |

NS = north-south antenna.
EW = east-west antenna.
NEW = northern EW antenna element.
SEW = southern EW antenna element.
B = NS + EW antennas, standard phasing.
EX = extrapolated data.

- = measurement point not established.
/ = measurement not taken.
* = data cannot be extrapolated.

**TABLE D-8. 76 Hz MAGNETIC FLUX DENSITIES (mG)**
**Upland Flora and Soil Microflora Studies**
**(page 1 of 2)**

| SITE NO., MEAS.PT. | 1986 NS 4 amps | 1986 NEW 6 amps | 1986 SEW 6 amps | 1986 SEW 10 amps (EX) | 1987 NS 15 amps | 1987 EW 15 amps | 1988 NS 75 amps | 1988 EW 75 amps | 1989 B 150 amps | 1990 B 150 amps |
|---|---|---|---|---|---|---|---|---|---|---|
| 4C1-6 | <0.001 | <0.001 | <0.001 | * | <0.001 | <0.001 | 0.001 | 0.001 | 0.003 | 0.003 |
| 4C1-7 | <0.001 | <0.001 | <0.001 | * | <0.001 | <0.001 | 0.001 | <0.001 | 0.002 | 0.002 |
| 4C1-8 | <0.001 | <0.001 | <0.001 | * | <0.001 | <0.001 | 0.001 | <0.001 | 0.002 | 0.002 |
| 4C1-9 | <0.001 | <0.001 | <0.001 | * | <0.001 | <0.001 | 0.001 | 0.001 | 0.003 | 0.003 |
| 4C1-10 | <0.001 | <0.001 | <0.001 | * | <0.001 | <0.001 | 0.001 | <0.001 | 0.002 | 0.002 |
| 4C1-11 | <0.001 | <0.001 | <0.001 | * | <0.001 | <0.001 | 0.001 | <0.001 | 0.002 | 0.002 |
| 4C1-12 | <0.001 | <0.001 | <0.001 | * | <0.001 | <0.001 | 0.001 | <0.001 | 0.002 | 0.002 |
| 4C1-13 | <0.001 | <0.001 | <0.001 | * | <0.001 | <0.001 | 0.001 | 0.001 | 0.003 | 0.003 |
| 4T2-3 | 0.047 | 0.001 | 0.22 | 0.37 | 0.008 | 0.55 | 0.040 | 2.8 | 5.7 | 5.9 |
| 4T2-4 | 0.049 | 0.001 | 0.24 | 0.40 | 0.008 | 0.57 | 0.041 | 2.9 | 5.8 | 5.9 |
| 4T2-5 | 0.197 | <0.001 | 1.00 | 1.67 | 0.011 | 2.4 | 0.061 | 12.4 | 24 | 27 |
| 4T2-6 | 0.058 | 0.001 | 0.44 | 0.73 | 0.006 | 1.16 | 0.020 | 5.0 | 10.3 | 11 |
| 4T2-7 | 0.046 | 0.001 | 0.22 | 0.37 | 0.006 | 0.59 | 0.024 | 2.6 | 5.4 | 5.8 |
| 4T2-8 | 0.045 | 0.001 | 0.22 | 0.37 | 0.006 | 0.59 | / | / | 5.6 | 5.8 |
| 4T2-9 | 0.029 | 0.001 | 0.138 | 0.23 | 0.007 | 0.38 | 0.027 | 1.72 | 3.4 | 3.6 |
| 4T2-10 | 0.033 | 0.001 | 0.149 | 0.25 | 0.006 | 0.39 | 0.027 | 1.78 | 3.5 | 3.7 |
| 4T2-11 | 0.043 | 0.001 | 0.21 | 0.35 | 0.006 | 0.56 | 0.025 | 2.6 | 5.0 | 5.3 |
| 4T2-12 | 0.047 | 0.001 | 0.23 | 0.38 | 0.006 | 0.61 | / | / | 5.6 | 5.9 |
| 4T2-13 | 0.086 | <0.001 | 0.43 | 0.72 | 0.005 | 1.14 | 0.020 | 5.1 | 10.1 | 10.8 |
| 4T2-14 | 0.21 | <0.001 | 1.03 | 1.72 | 0.012 | 2.5 | 0.061 | 11.9 | 25 | 28 |
| 4T2-15 | - | - | - | - | - | - | - | - | 33 | 36 |
| 4T2-16 | - | - | - | - | - | - | - | - | 28 | 29 |
| 4T2-17 | - | - | - | - | - | - | - | - | 13.6 | 13.9 |
| 4T2-18 | - | - | - | - | - | - | - | - | 8.6 | 8.6 |
| 4T2-19 | - | - | - | - | - | - | - | - | 5.9 | 6.0 |
| 4T2-26 | - | - | - | - | - | - | - | - | - | 10.5 |
| 4T2-33 | - | - | - | - | - | - | - | - | - | 4.2 |
| 4T2-34 | - | - | - | - | - | - | - | - | - | 7.4 |
| 4T2-35 | - | - | - | - | - | - | - | - | - | 21 |
| 4T2-36 | - | - | - | - | - | - | - | - | - | 36 |

NS = north-south antenna.
EW = east-west antenna.
NEW = northern EW antenna element.
SEW = southern EW antenna element.
B = NS + EW antennas, standard phasing.
EX = extrapolated data.

\- = measurement point not established.
/ = measurement not taken.
* = data cannot be extrapolated.

**TABLE D-8. 76 Hz MAGNETIC FLUX DENSITIES (mG)**
**Upland Flora and Soil Microflora Studies**
**(page 2 of 2)**

| SITE NO., MEAS.PT. | 1986 NS 4 amps | 1986 NEW 6 amps | 1986 SEW 6 amps | 1986 SEW 10 amps (EX) | 1987 NS 15 amps | 1987 EW 15 amps | 1988 NS 75 amps | 1988 EW 75 amps | 1989 B 150 amps | 1990 B 150 amps |
|---|---|---|---|---|---|---|---|---|---|---|
| 4T4-4 | 0.019 | <0.001 | 0.096 | 0.160 | 0.005 | 0.24 | 0.027 | 1.15 | 2.5 | 2.3 |
| 4T4-5 | 0.114 | 0.001 | 0.57 | 0.95 | 0.008 | 1.40 | 0.033 | 6.9 | 13.9 | 13.3 |
| 4T4-6 | 0.045 | 0.001 | 0.22 | 0.37 | 0.008 | 0.53 | 0.034 | 2.7 | 5.3 | 5.1 |
| 4T4-7 | 0.038 | 0.001 | 0.186 | 0.31 | 0.008 | 0.45 | 0.033 | 2.3 | 4.4 | 4.1 |
| 4T4-8 | 0.035 | 0.001 | 0.179 | 0.30 | 0.007 | 0.43 | 0.033 | 2.1 | 4.2 | 4.1 |
| 4T4-9 | 0.025 | 0.21 | 0.118 | 0.197 | 0.005 | 0.29 | 0.027 | 1.41 | 2.8 | 2.7 |
| 4T4-10 | 0.022 | <0.001 | 0.116 | 0.193 | 0.005 | 0.27 | 0.027 | 1.33 | 2.7 | 2.6 |
| 4T4-11 | 0.161 | 0.001 | 0.80 | 1.33 | 0.011 | 1.89 | 0.042 | 8.9 | 18.7 | 19.1 |
| 4T4-12 | 0.115 | 0.001 | 0.58 | 0.97 | 0.010 | 1.37 | 0.041 | 7.1 | 14.5 | 13.4 |
| 4T4-13 | - | - | - | - | - | - | - | - | 2.7 | 3.8 |
| 4T4-14 | - | - | - | - | - | - | - | - | 7.0 | 7.0 |
| 4T4-15 | - | - | - | - | - | - | - | - | 11.9 | 12.0 |
| 4T4-16 | - | - | - | - | - | - | - | - | 18 | 14.6 |
| 4T4-17 | - | - | - | - | - | - | - | - | 14.3 | 13.6 |
| 4T4-18 | - | - | - | - | - | - | - | - | 16.8 | 15.7 |
| 4T4-19 | - | - | - | - | - | - | - | - | 9.8 | 9.1 |
| 4T4-20 | - | - | - | - | - | - | - | - | 5.9 | 5.4 |
| 4S1-1 | - | - | - | - | <0.001 | <0.001 | <0.001 | <0.001 | / | / |
| 4S2-1 | - | - | - | - | <0.001 | <0.001 | 0.001 | <0.001 | 0.002 | 0.001 |
| 4S3-1 | - | - | - | - | <0.001 | <0.001 | <0.001 | <0.001 | / | / |

NS = north-south antenna.
EW = east-west antenna.
NEW = northern EW antenna element.
SEW = southern EW antenna element.
B = NS + EW antennas, standard phasing.
EX = extrapolated data.

- = measurement point not established.
/ = measurement not taken.
* = data cannot be extrapolated.

**TABLE D-9. 76 Hz EARTH ELECTRIC FIELD INTENSITIES (mV/m)**
**Upland Flora and Soil Microflora Antenna Site Fixed Test Points**
**(page 1 of 3)**

| Test Point | 28 Jun 90 | 10 Jul 90 | 24 Jul 90 | 07 Aug 90 | 21 Aug 90 | 04 Sep 90 | 18 Sep 90 |
|---|---|---|---|---|---|---|---|
| 4T2-3 | 140 | 135 | 139 | 145 | 142 | 141 | 139 |
| 4T2-4 | 129 | 128 | 124 | 125 | 126 | 127 | 126 |
| 4T2-5 | 105 | 99 | 97 | 94 | 102 | 99 | 104 |
| 4T2-6 | 101 | 100 | 96 | 97 | 100 | 94 | 96 |
| 4T2-7 | 89 | 86 | 84 | 82 | 80 | 84 | 81 |
| 4T2-8 | 135 | 130 | 142 | 143 | 132 | 138 | 133 |
| 4T2-9 | 125 | 122 | 119 | 116 | 120 | 118 | 117 |
| 4T2-10 | 91 | 87 | 88 | 88 | 87 | 89 | 88 |
| 4T2-11 | 170 | 168 | 160 | 158 | 168 | 165 | 168 |
| 4T2-12 | 114 | 114 | 113 | 114 | 110 | 110 | 106 |
| 4T2-13 | 144 | 142 | 144 | 145 | 144 | 146 | 146 |
| 4T2-14 | 121 | 115 | 117 | 113 | 118 | 117 | 122 |
| 4T2-16 | 91 | 88 | 85 | 81 | 90 | 91 | 90 |
| 4T2-19 | 107 | 106 | 106 | 103 | 106 | 105 | 106 |
| 4T2-20 | 107 | 107 | 102 | 108 | 107 | 105 | 106 |
| 4T2-21 | 143 | 139 | 122 | 132 | 139 | 142 | 139 |
| 4T2-22 | 98 | 92 | 91 | 85 | 93 | 86 | 89 |
| 4T2-23 | 114 | 108 | 109 | 107 | 112 | 109 | 115 |
| 4T2-24 | 120 | 121 | 114 | 112 | 117 | 117 | 120 |
| 4T2-25 | 115 | 60 | 117 | 121 | 116 | 114 | 115 |
| 4T2-26 | 210 | 204 | 203 | 213 | 206 | 199 | 198 |
| 4T2-27 | 118 | 112 | 124 | 130 | 119 | 116 | 115 |
| 4T2-28 | 151 | 151 | 153 | 157 | 152 | 153 | 152 |
| 4T2-29 | 55 | 55 | 61 | 63 | 53 | 53 | 54 |
| 4T2-30 | 106 | 105 | 113 | 122 | 110 | 107 | 112 |
| 4T2-31 | 94 | 96 | 98 | 99 | 99 | 100 | 101 |
| 4T2-32 | 75 | 73 | 73 | 72 | 74 | 74 | 75 |

TABLE D-9. 76 Hz EARTH ELECTRIC FIELD INTENSITIES (mV/m)
Upland Flora and Soil Microflora Antenna Site Fixed Test Points
(page 2 of 3)

| Test Point | 02 Oct 90 | 22 Oct 90 | 07 Nov 90 | 05 Dec 90 | 21 Dec 90 | 04 Jan 91 | 18 Jan 91 |
|---|---|---|---|---|---|---|---|
| 4T2-3 | 141 | 143 | 147 | 153 | 157 | 147 | 144 |
| 4T2-4 | 126 | 126 | 125 | 120 | 121 | 112 | 117 |
| 4T2-5 | 105 | 111 | 108 | 110 | 106 | 108 | 111 |
| 4T2-6 | 97 | 106 | 104 | 104 | 105 | 112 | 119 |
| 4T2-7 | 85 | 87 | 87 | 88 | 83 | 95 | 101 |
| 4T2-8 | 137 | 141 | 143 | 141 | 145 | 149 | 150 |
| 4T2-9 | 119 | 122 | 122 | 136 | 141 | 137 | 134 |
| 4T2-10 | 92 | 97 | 95 | 96 | 98 | 100 | 99 |
| 4T2-11 | 168 | 177 | 171 | 123 | 125 | 139 | 131 |
| 4T2-12 | 108 | 114 | 116 | 154 | 163 | 161 | 162 |
| 4T2-13 | 143 | 147 | 146 | 156 | 160 | 180 | 169 |
| 4T2-14 | 124 | 127 | 126 | 122 | 125 | 113 | 121 |
| 4T2-16 | 96 | 97 | 99 | 94 | 95 | 81 | 85 |
| 4T2-19 | 106 | 107 | 107 | 105 | 106 | 98 | 103 |
| 4T2-20 | 107 | 111 | 110 | 114 | 121 | 129 | 122 |
| 4T2-21 | 140 | 149 | 144 | 141 | 144 | 141 | 128 |
| 4T2-22 | 93 | 90 | 89 | 85 | 85 | 86 | 89 |
| 4T2-23 | 115 | 126 | 122 | 113 | 115 | 106 | 107 |
| 4T2-24 | 123 | 127 | 126 | 128 | 123 | 121 | 130 |
| 4T2-25 | 114 | 118 | 120 | 129 | 129 | 138 | 135 |
| 4T2-26 | 197 | 210 | 219 | 226 | 224 | 249 | 239 |
| 4T2-27 | 116 | 129 | 133 | 124 | 131 | 149 | 146 |
| 4T2-28 | 153 | 149 | 151 | 152 | 149 | 178 | 168 |
| 4T2-29 | 53 | 53 | 59 | 53 | 54 | 70 | 70 |
| 4T2-30 | 113 | 115 | 124 | 120 | 122 | 130 | 129 |
| 4T2-31 | 100 | 102 | 102 | 103 | 104 | 103 | 104 |
| 4T2-32 | 74 | 75 | 73 | 72 | 75 | 58 | 63 |

**TABLE D-9. 76 Hz EARTH ELECTRIC FIELD INTENSITIES (mV/m)**
**Upland Flora and Soil Microflora Antenna Site Fixed Test Points**
**(page 3 of 3)**

| Test Point | Average | Standard Deviation | Coefficient of Variability |
|---|---|---|---|
| 4T2-3 | 144 | 5.8 | 0.04 |
| 4T2-4 | 124 | 4.7 | 0.04 |
| 4T2-5 | 104 | 5.4 | 0.05 |
| 4T2-6 | 102 | 6.9 | 0.07 |
| 4T2-7 | 87 | 5.6 | 0.06 |
| 4T2-8 | 140 | 6.1 | 0.04 |
| 4T2-9 | 125 | 8.4 | 0.07 |
| 4T2-10 | 93 | 4.8 | 0.05 |
| 4T2-11 | 157 | 18.6 | 0.12 |
| 4T2-12 | 126 | 23 | 0.18 |
| 4T2-13 | 151 | 11.4 | 0.08 |
| 4T2-14 | 120 | 4.6 | 0.04 |
| 4T2-16 | 90 | 5.7 | 0.06 |
| 4T2-19 | 105 | 2.4 | 0.02 |
| 4T2-20 | 111 | 7.7 | 0.07 |
| 4T2-21 | 139 | 7.0 | 0.05 |
| 4T2-22 | 89 | 3.8 | 0.04 |
| 4T2-23 | 113 | 5.8 | 0.05 |
| 4T2-24 | 121 | 5.3 | 0.04 |
| 4T2-25 | 117 | 18.3 | 0.16 |
| 4T2-26 | 214 | 15.7 | 0.07 |
| 4T2-27 | 126 | 11.3 | 0.09 |
| 4T2-28 | 155 | 8.1 | 0.05 |
| 4T2-29 | 58 | 6.2 | 0.11 |
| 4T2-30 | 116 | 8.3 | 0.07 |
| 4T2-31 | 100 | 3.0 | 0.03 |
| 4T2-32 | 72 | 5.0 | 0.07 |

**TABLE D-10. 76 Hz EARTH ELECTRIC FIELD INTENSITIES (mV/m)**
**Upland Flora and Soil Microflora Ground Site Fixed Test Points**
**(page 1 of 3)**

| Test Point | 28 Jun 90 | 10 Jul 90 | 24 Jul 90 | 07 Aug 90 | 21 Aug 90 | 04 Sep 90 | 18 Sep 90 |
|---|---|---|---|---|---|---|---|
| 4T4-4 | 31 | 29 | 27 | 28 | 31 | 31 | 32 |
| 4T4-5 | 1670 | 1796 | 1830 | 1954 | 2100 | 2039 | 2021 |
| 4T4-6 | 117 | 115 | 115 | 125 | 136 | 138 | 141 |
| 4T4-7 | 135 | 132 | 130 | 132 | 137 | 135 | 137 |
| 4T4-8 | 113 | 108 | 105 | 106 | 109 | 105 | 108 |
| 4T4-9 | 42 | 42 | 42 | 43 | 42 | 43 | 43 |
| 4T4-10 | 32 | 30 | 30 | 30 | 30 | 29 | 32 |
| 4T4-11 | 1890 | 1941 | 2191 | 2304 | 2030 | 2084 | 2045 |
| 4T4-12 | 1600 | 1611 | 1698 | 1815 | 1850 | 1822 | 1899 |
| 4T4-21 | 109 | 107 | 91 | 97 | 122 | 127 | 131 |
| 4T4-22 | 148 | 137 | 139 | 148 | 153 | 154 | 159 |
| 4T4-23 | 333 | 337 | 329 | 351 | 380 | 368 | 385 |
| 4T4-24 | 360 | 360 | 344 | 344 | 393 | 381 | 409 |

**TABLE D-10. 76 Hz EARTH ELECTRIC FIELD INTENSITIES (mV/m)**
**Upland Flora and Soil Microflora Ground Site Fixed Test Points**
**(page 2 of 3)**

| Test Point | 02 Oct 90 | 22 Oct 90 | 07 Nov 90 | 05 Dec 90 | 21 Dec 90 | 04 Jan 91 | 18 Jan 91 |
|---|---|---|---|---|---|---|---|
| 4T4-4 | 32 | 12.0 | 9.0 | 8.7 | 8.3 | 6.8 | 7.1 |
| 4T4-5 | 1975 | 1721 | 1742 | 1981 | 1912 | 2110 | 2102 |
| 4T4-6 | 143 | 148 | 140 | 142 | 140 | 131 | 131 |
| 4T4-7 | 139 | 144 | 146 | 145 | 149 | 136 | 147 |
| 4T4-8 | 109 | 112 | 113 | 109 | 111 | 108 | 112 |
| 4T4-9 | 44 | 18.0 | 20 | 20 | 22 | 25 | 25 |
| 4T4-10 | 33 | 35 | 37 | 37 | 37 | 37 | 36 |
| 4T4-11 | 2030 | 2186 | 2237 | 2409 | 2542 | 2640 | 2836 |
| 4T4-12 | 1958 | 1822 | 1772 | 1820 | 1861 | 2460 | 2303 |
| 4T4-21 | 134 | 146 | 135 | 132 | 136 | 128 | 123 |
| 4T4-22 | 169 | 177 | 174 | 170 | 165 | 154 | 148 |
| 4T4-23 | 396 | 413 | 382 | 374 | 385 | 390 | 378 |
| 4T4-24 | 428 | 432 | 420 | 420 | 416 | 454 | 438 |

**TABLE D-10. 76 Hz EARTH ELECTRIC FIELD INTENSITIES (mV/m)**
**Upland Flora and Soil Microflora Ground Site Fixed Test Points**
**(page 3 of 3)**

| Test Point | Average | Standard Deviation | Coefficient of Variability |
|---|---|---|---|
| 4T4-4 | 21 | 11.2 | 0.53 |
| 4T4-5 | 1930 | 150 | 0.08 |
| 4T4-6 | 133 | 11 | 0.08 |
| 4T4-7 | 139 | 6.2 | 0.04 |
| 4T4-8 | 109 | 2.7 | 0.02 |
| 4T4-9 | 34 | 10.9 | 0.32 |
| 4T4-10 | 33 | 3.2 | 0.10 |
| 4T4-11 | 2200 | 280 | 0.13 |
| 4T4-12 | 1880 | 240 | 0.13 |
| 4T4-21 | 123 | 15.9 | 0.13 |
| 4T4-22 | 157 | 12.6 | 0.08 |
| 4T4-23 | 370 | 25 | 0.07 |
| 4T4-24 | 400 | 36 | 0.09 |

# APPENDIX E

# AQUATIC ECOSYSTEMS STUDIES

## AQUATIC ECOSYSTEMS STUDIES

The approach of the aquatic ecosystems studies is to integrate the major interrelated and interactive components of aquatic ecosystems (periphytic algae, aquatic insects, and fish) and to monitor events and processes critical to stream ecosystems. The earth electric field and the magnetic field are considered the most important factors influencing the aquatic ecosystems studies. The electric field in the air is not expected to have any impact on the components of these studies.

IITRI field crews made ELF electromagnetic (EM) field measurements at 19 measurement points within four treatment and five control sites for the aquatic ecosystems studies in 1990. The measurement points differed from those used in 1989 in that seven measurement points were dropped (5C1-2, 5C1-6, 5T1-1, 5T2-3, 5T4-1, 5T6-1, 5T7-1), six were added (5C1-7 and 5T2-4 through 8), and one measurement point was re-established (5T4-2). This large number of changes is the result of fine-tuning study locations to improve intersite EM field exposure ratios and dropping measurement points at abandoned sites. Measurement point location changes are discussed in detail in Section 2 of this report. Measurement dates for 1990 and previous years appear in Table E-1.

**TABLE E-1. EM FIELD MEASUREMENT DATES**
**Aquatic Ecosystems Studies**

| Year | Measurement Dates | |
|---|---|---|
| 1983 | Jun 13, 15, 16 | |
| 1984 | May 16, 17 | Aug 21, 22 |
| 1985 | Jul 22, 23 | |
| 1986 | Oct 8-10 | |
| 1987 | Sep 28, 29 | |
| 1988 | Sep 26, 28-30 | |
| 1989 | Sep 11-13 | |
| 1990 | May 8, 9, 11 | |

The positions of the nine sites relative to the NRTF-Republic are shown on the composite map in Figure E-1. The site numbers listed on the map are those used by IITRI. Table E-2 provides a cross-reference of IITRI site numbers, investigator site names, and township, range, and section numbers for the sites. Details of measurement locations within sites are given in Figures E-2 through E-8.

EM field measurements for 1990 and previous years are found in Tables E-3 through E-8. Tables E-3, E-4, and E-5 present 60 Hz data for the air electric field, earth electric field, and magnetic flux density,

respectively. Tables E-6, E-7, and E-8 present 76 Hz data for these fields as well as the corresponding operating currents of the NRTF-Republic for each year.

Ambient 60 Hz EM field intensities were measured only at the transmission line location (5C15-1) in 1990. The earth electric field and magnetic flux density measurements at this location were consistent between 1989 and 1990. The air electric field intensity measured at this location in 1990, however, is considerably greater than that measured in 1989. This may be explained by a change in the measurement location to the middle of the river instead of on the riverbank, where tall brush may have had a significant shielding effect.

The 76 Hz EM field measurements in 1990 were made with 150 ampere antenna currents, the predominant operating current of the NRTF-Republic since 4 May 1989. The antenna currents at which measurements were made in each year are given in the column headings of Tables E-6 through E-8. The annual increases in field magnitudes reflect the level of antenna current at the time of measurement: 4 or 6 amperes in 1986, 15 amperes in 1987, 75 amperes in 1988, and 150 amperes in 1989 and 1990. The 1990 measurements are consistent with the 1989 measurements at the same current, and proportional to the 1986, 1987, and 1988 measurements made at lower currents.

The 76 Hz EM field intensities at the newly established measurement locations and their effect on the EM exposure ratios are discussed in Section 2 of this report.

**TABLE E-2. SITE NO. CROSS-REFERENCE**
**Aquatic Ecosystems Studies**

| IITRI Site No. | Investigator's Site Name | | Location Township | : | Range | : | Section(s) |
|---|---|---|---|---|---|---|---|
| | **Ambient Monitoring** | | | | | | |
| 5T2-1 | FEX 2 | | T43N | : | R29W | : | 14 |
| 5C1-1 | FCD | | T43N | : | R28W | : | 21 |
| | **Insect Substrates and Leaf Packs** | | | | | | |
| 5T1-2 | FEX 1 | | T43N | : | R29W | : | 14 |
| 5T2-7 | FEX 2 | | T43N | : | R29W | : | 14 |
| 5C1-5 | FCD | | T43N | : | R28W | : | 21 |
| | **Periphyton and PR** | | | | | | |
| 5T2-2 | FEX 2 | | T43N | : | R29W | : | 14 |
| 5T2-7 | FEX N | | T43N | : | R29W | : | 14 |
| 5C1-3 | FCD N | | T43N | : | R28W | : | 21 |
| 5C1-5 | FCD | | T43N | : | R28W | : | 21 |
| | **Periphyton Grazing** | | | | | | |
| 5T2-8 | FEX 2 | | T43N | : | R29W | : | 14 |
| 5C1-3 | FCD N | | T43N | : | R28W | : | 21 |
| 5C1-5 | FCD | | T43N | : | R28W | : | 21 |
| | **Fish Movement** | | | | | | |
| 5T2-4 | FEX 2 | | T43N | : | R29W | : | 14 |
| 5T3-1 | FEX 3 | | T43N | : | R29W | : | 14 |
| 5T4-2 | FEX 4 | | T43N | : | R29W | : | 11, 14 |
| 5C1-4 | FCD | | T43N | : | R28W | : | 21 |
| 5C3-2 | FCU | | T43N | : | R29W | : | 18 |
| 5C5-1 | FS1 (inactive) | | T43N | : | R29W | : | 16 |
| 5C14-1 | TM | | T43N | : | R29W | : | 8 |
| 5C15-1 | T-Line | | T43N | : | R29W | : | 17 |
| | **Fish Population** | | | | | | |
| 5T3-1 | FEX 3 | | T43N | : | R29W | : | 14 |
| 5C1-4 | FCD | | T43N | : | R28W | : | 21 |
| 5T2-5 | Unused | | T43N | : | R29W | : | 14 |
| 5T2-6 | Unused | | T43N | : | R29W | : | 14 |
| 5T7-1 | Unused | | T43N | : | R29W | : | 11 |
| 5C1-7 | Unused | | T43N | : | R28W | : | 21 |
| 5T2-3 | FEX 2; Insect Movement | (abandoned) | T43N | : | R29W | : | 14 |
| 5C1-3 | FCU; Insect Movement | (abandoned) | T43N | : | R28W | : | 21 |
| 5C1-6 | FCU; Insect Movement | (abandoned) | T43N | : | R28W | : | 21 |
| 5T1-1 | FEX 1; Fish Parasites | (abandoned) | T43N | : | R29W | : | 11 |
| 5T4-1 | FEX 4; Fish Parasites | (abandoned) | T43N | : | R29W | : | 14 |
| 5T6-1 | FEX 6; Fish Parasites | (abandoned) | T43N | : | R29W | : | 12, 13 |
| 5C1-2 | FCU; Fish Parasites | (abandoned) | T43N | : | R28W | : | 21 |
| 5T4-2 | FEX 4; Fish Feeding | (abandoned) | T43N | : | R29W | : | 11, 14 |

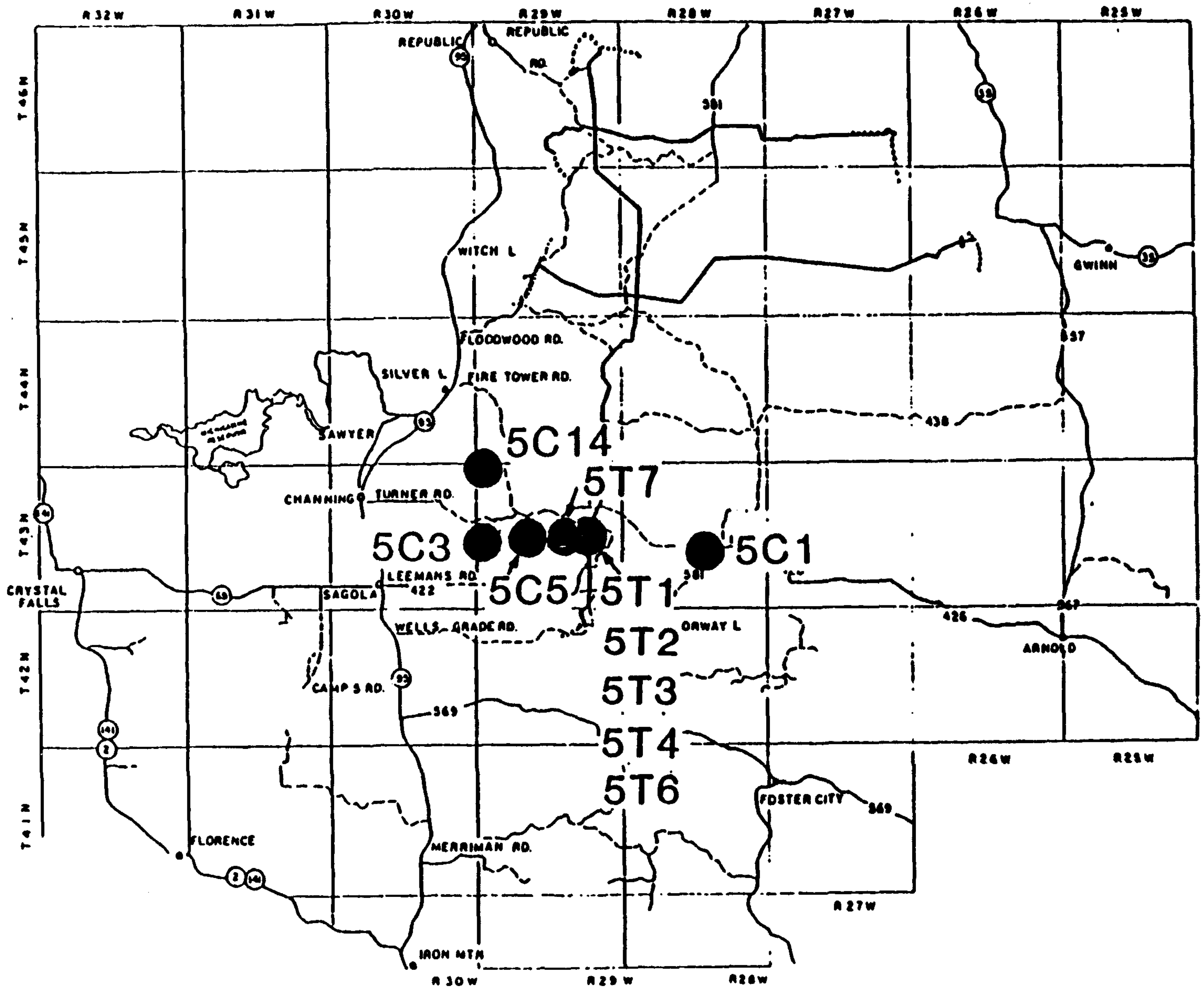



FIGURE E-1. POSITIONS OF AQUATIC ECOSYSTEMS RELATIVE TO NRTF-REPUBLIC ANTENNA ELEMENTS.

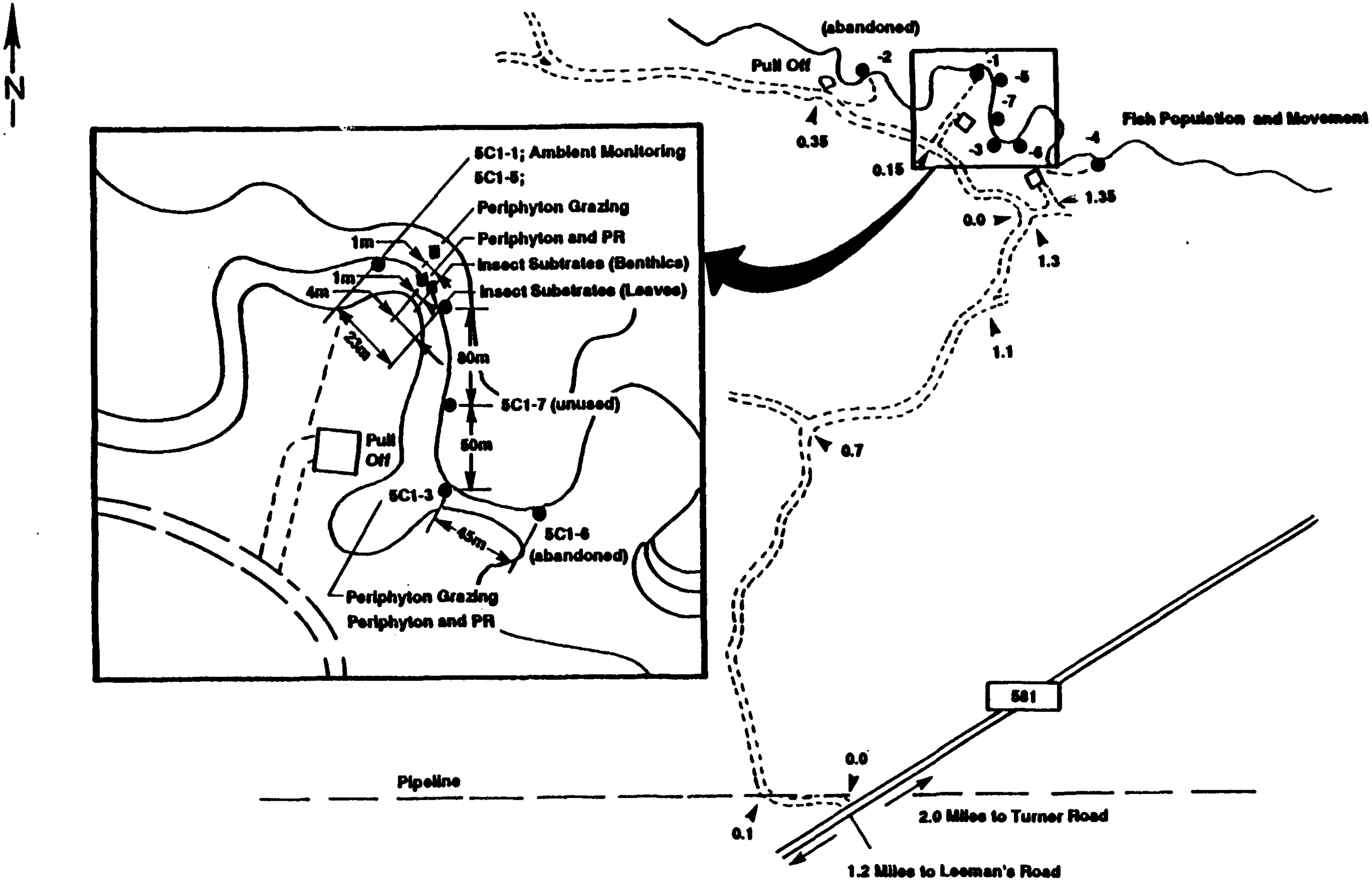



FIGURE E-2. MEASUREMENT POINTS AT FCD; 5C1-1 THROUGH 6.

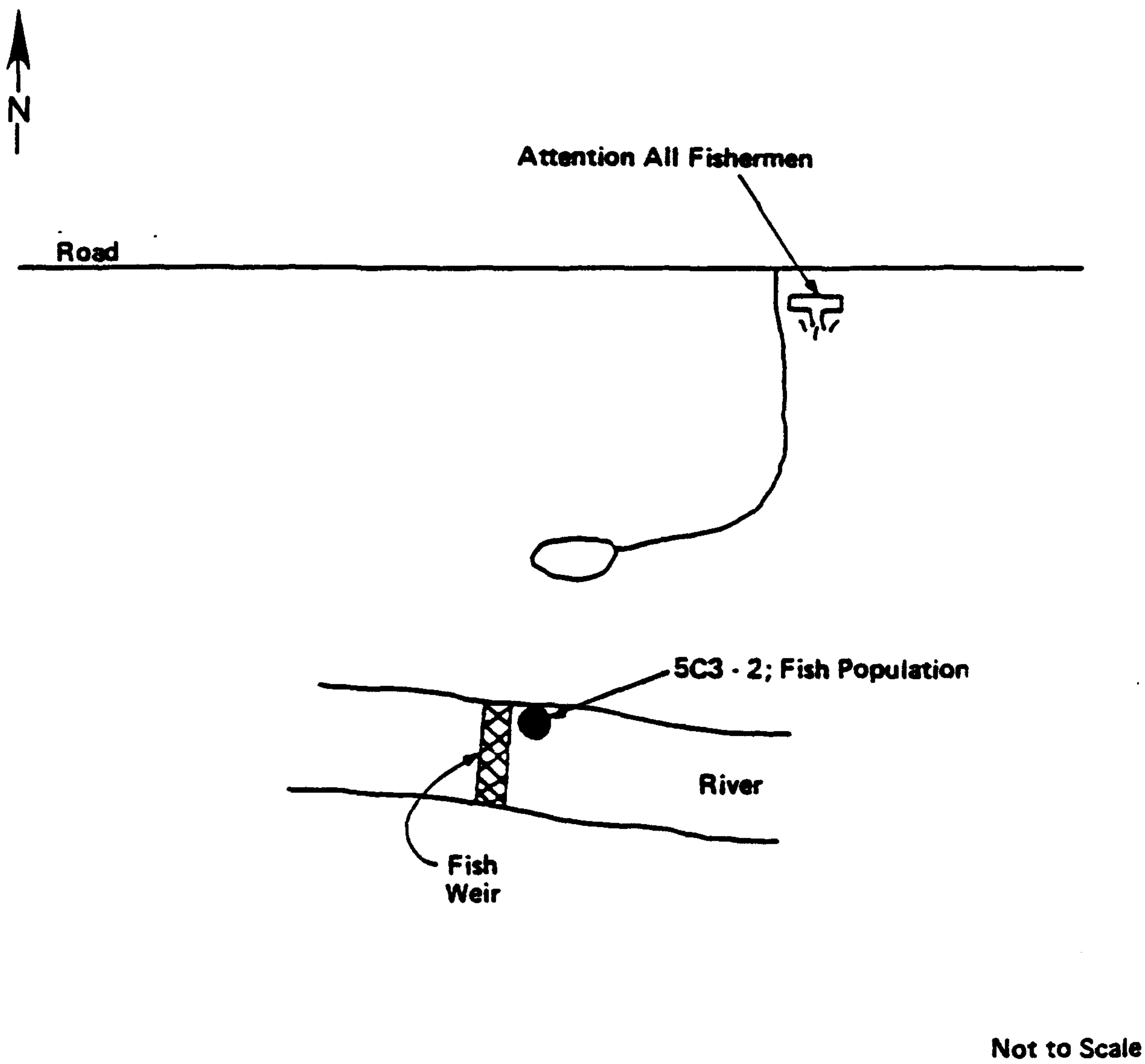



FIGURE E-3. MEASUREMENT POINT AT FCU; 5C3-2.

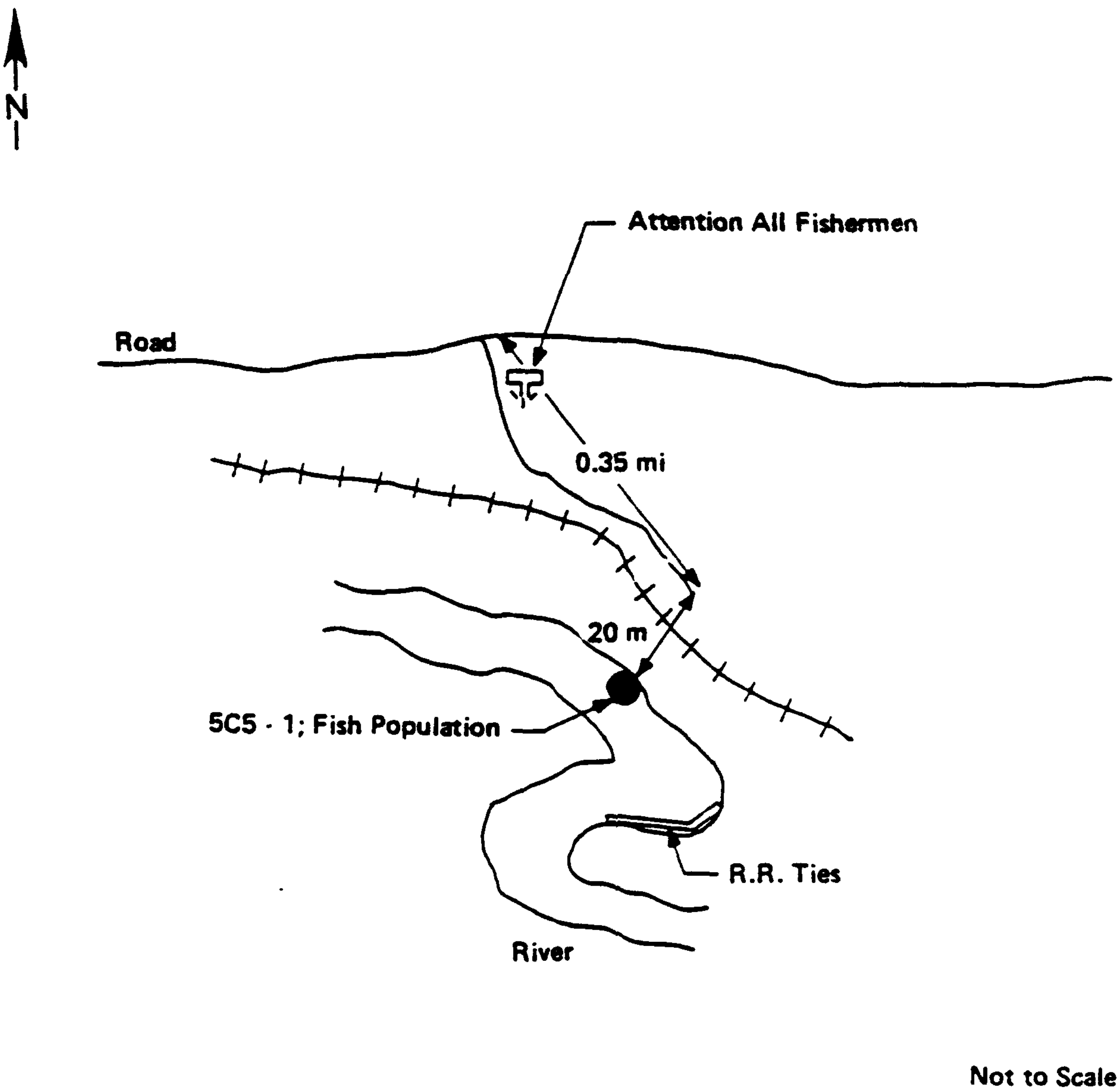



**FIGURE E-4. MEASUREMENT POINT AT FS1; 5C5-1.**

60297/790

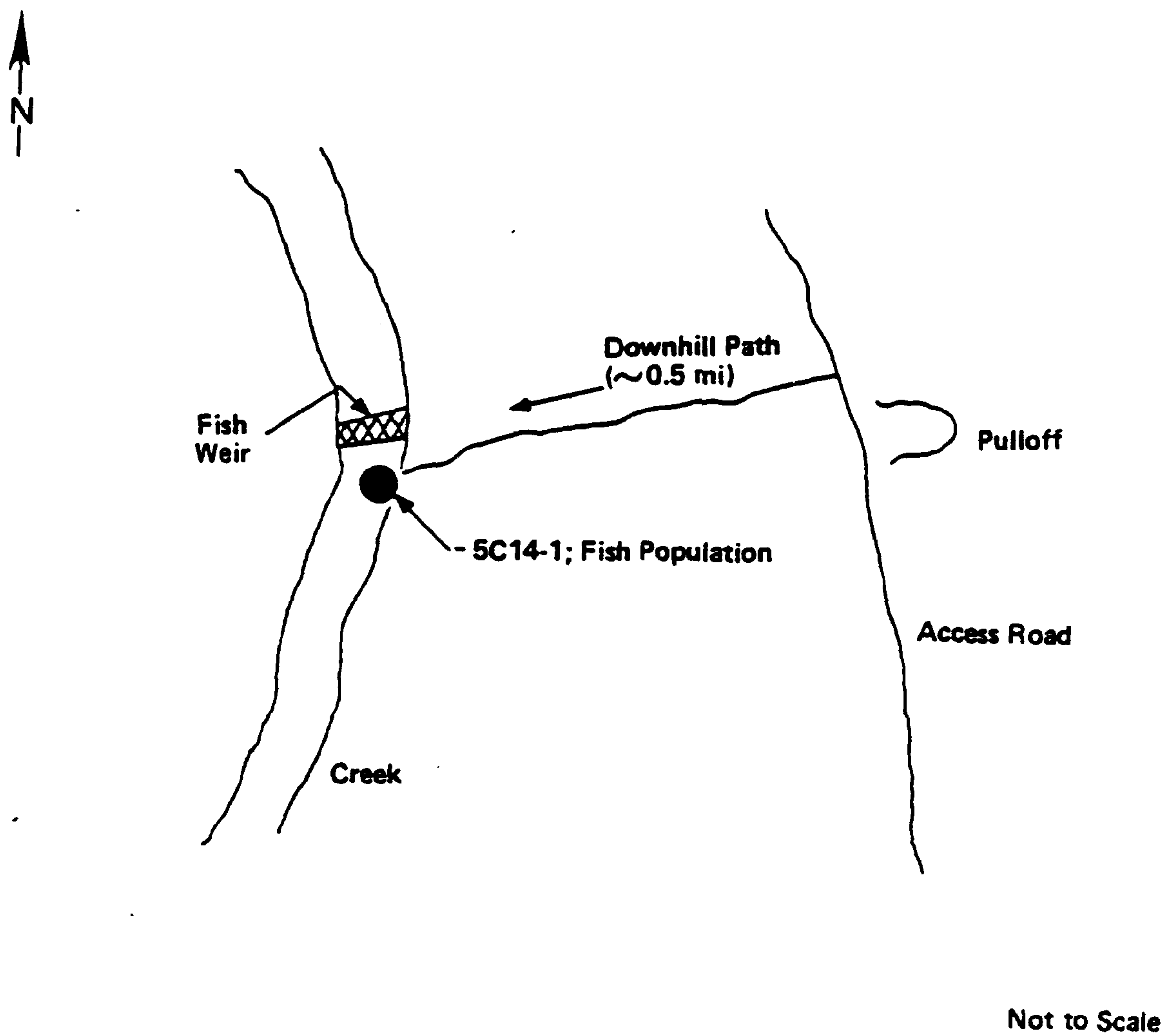



FIGURE E-5. MEASUREMENT POINT AT TM; 5C14-1.

60297/790

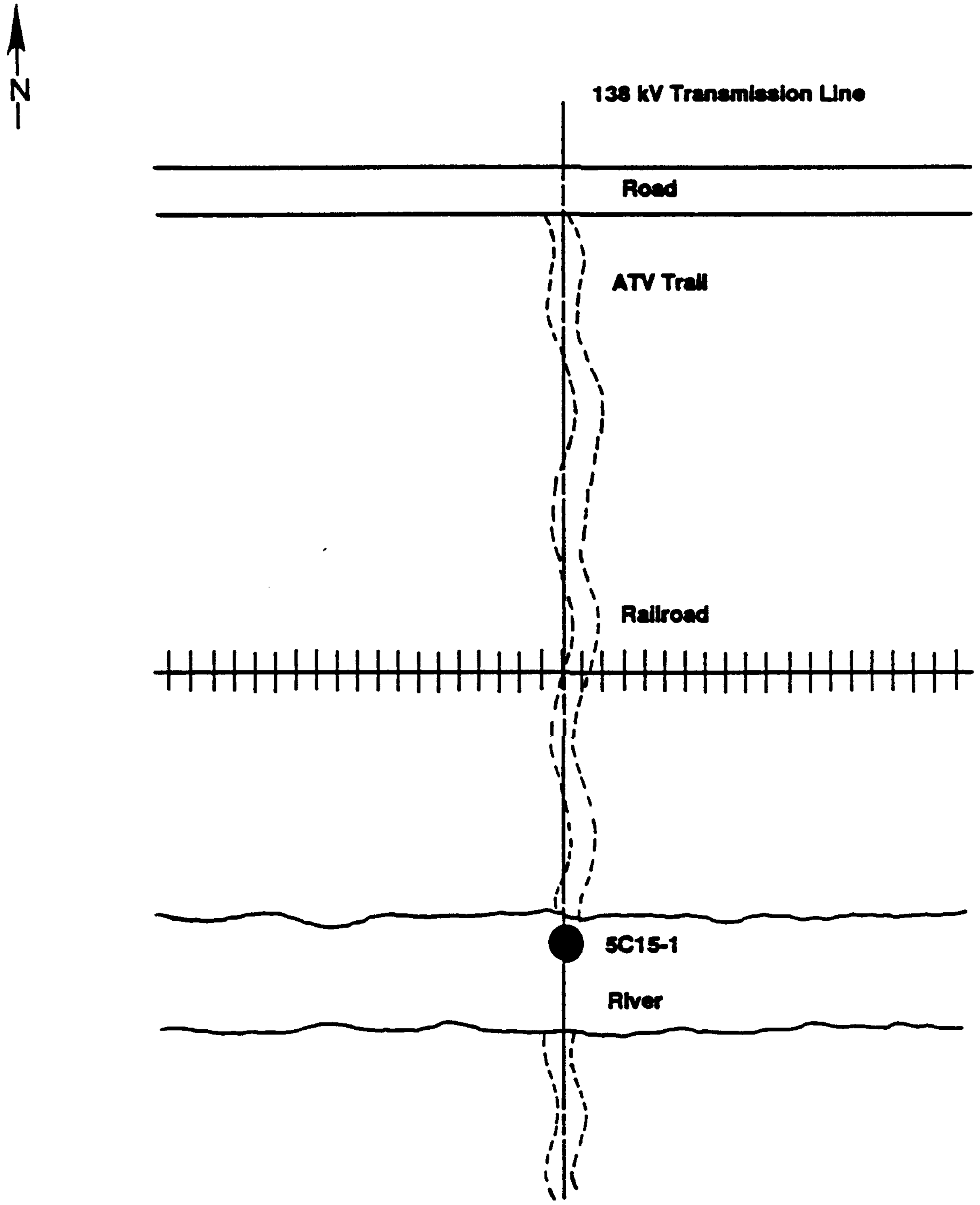



**FIGURE E-6. MEASUREMENT POINT AT TRANSMISSION LINE; 5C15-1.**

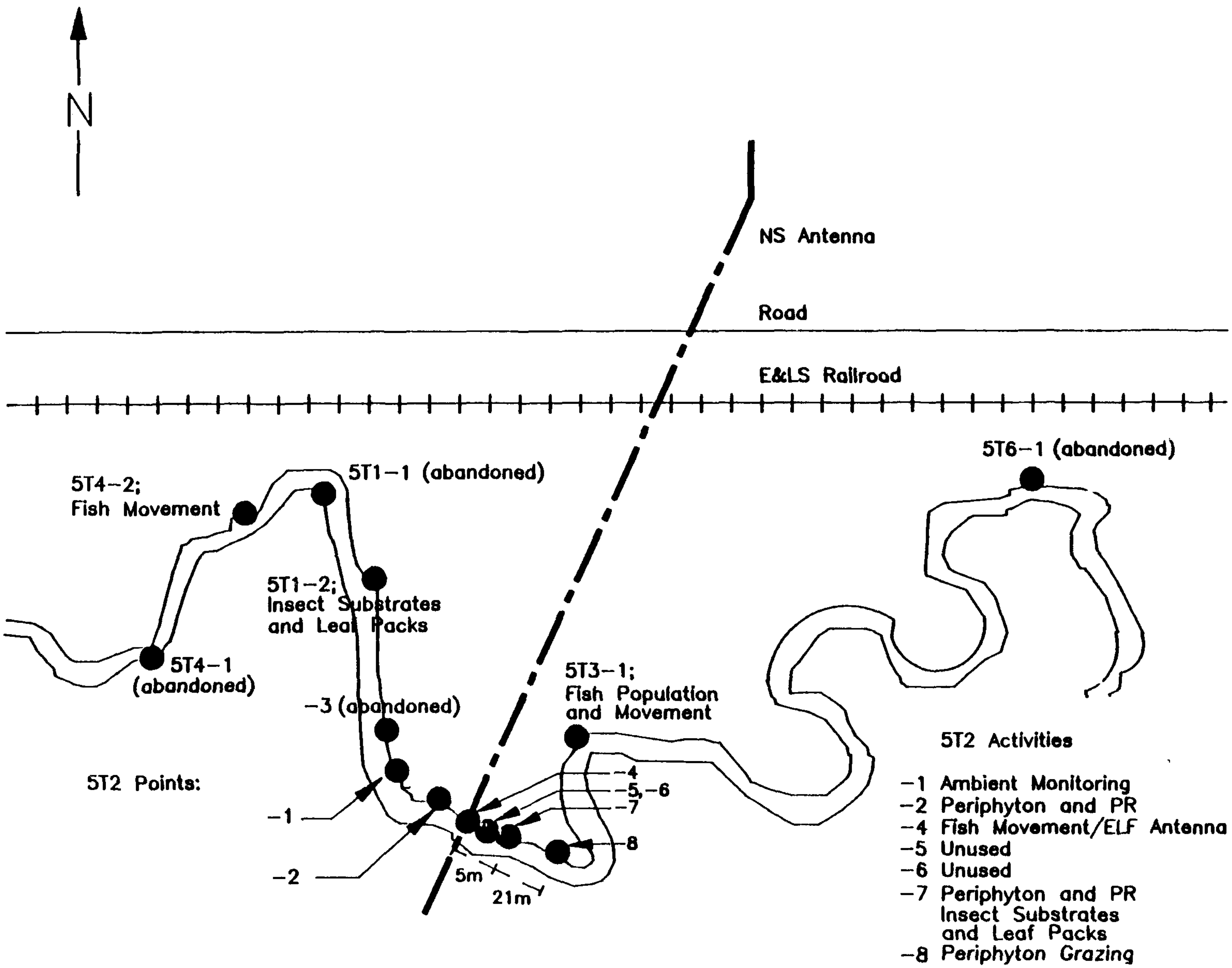



**FIGURE E-7. MEASUREMENT POINTS AT FEX; 5T1-1, 2; 5T2-1 THROUGH 8; 5T3-1; 5T4-1, 2; 5T6-1.**

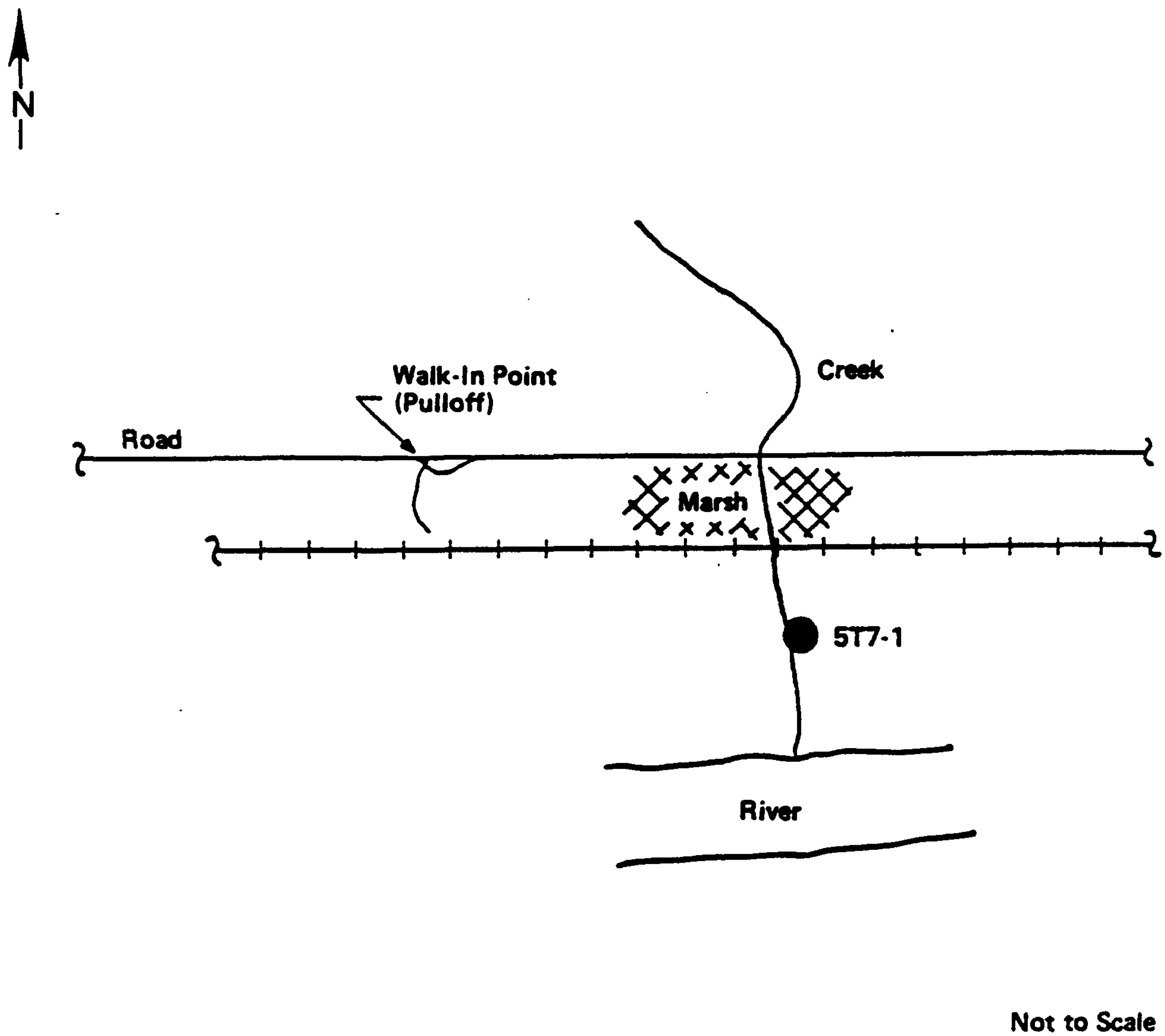



FIGURE E-8. MEASUREMENT POINT AT FEX 7; 5T7-1.

TABLE E-3. 60 Hz AIR ELECTRIC FIELD INTENSITIES (V/m)
Aquatic Ecosystems Studies

| Site No., Meas. Pt. | 1983[a] | 1984[a] | 1985[a] | 1986[b] | 1987[c] | 1988[c] | 1989[d] | 1990[d] |
|---|---|---|---|---|---|---|---|---|
| 5C1-1 | 0.002 | <0.001 | < | < | < | < | < | # |
| 5C' 2 | <0.001 | / | / | < | < | < | < | # |
| 5C1-3 | <0.001 | / | / | < | < | < | < | # |
| 5C1-4 | - | <0.001 | < | < | < | < | < | # |
| 5C1-5 | - | - | - | - | - | < | < | # |
| 5C1-6 | - | - | - | - | - | - | < | # |
| 5C1-7 | - | - | - | - | - | - | - | # |
| 5C3-2 | <0.001 | 0.003 | < | < | < | < | < | # |
| 5C5-1 | 0.001 | <0.001 | < | < | < | < | < | # |
| 5C14-1 | - | 0.033 | < | < | < | < | < | # |
| 5C15-1 | - | - | - | - | - | - | 6.5 | 50 |
| 5T1-1 | - | / | / | < | < | < | < | # |
| 5T1-2 | <0.001 | < | < | < | < | < | < | # |
| 5T2-1 | - | < | < | < | < | < | <0.001 | # |
| 5T2-2 | - | < | < | < | <0.001 | 0.002 | <0.001 | # |
| 5T2-3 | - | - | - | < | < | <0.001 | < | # |
| 5T2-4 | - | - | - | - | - | - | - | # |
| 5T2-5 | - | - | - | - | - | - | - | # |
| 5T2-6 | - | - | - | - | - | - | - | # |
| 5T2-7 | - | - | - | - | - | - | - | # |
| 5T2-8 | - | - | - | - | - | - | - | # |
| 5T3-1 | - | < | < | < | 0.001 | <0.001 | / | # |
| 5T4-1 | - | < | / | < | < | < | < | # |
| 5T4-2 | - | - | - | < | < | < | -- | # |
| 5T6-1 | - | <0.001 | < | < | < | <0.001 | < | # |
| 5T7-1 | - | - | - | < | < | <0.001 | < | # |

a = antennas not constructed.
b = antennas off, grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 A current.

\- = measurement point not established.
-- = measurement point dropped.
/ = measurement not taken.
\# = measurement precluded by antenna operation.
< = measurement est. <0.001 V/m based on earth E-field.

TABLE E-4. 60 Hz EARTH ELECTRIC FIELD INTENSITES (mV/m)
Aquatic Ecosystems Studies

| Site No., Meas. Pt. | 1983[a] | 1984[a] | 1985[a] | 1986[b] | 1987[c] | 1988[c] | 1989[d] | 1990[d] |
|---|---|---|---|---|---|---|---|---|
| 5C1-1 | 1.47,1.73 | 2.7 | 2.6 | 0.22 | 0.26 | 0.32 | 0.27 | # |
| 5C1-2 | 1.8 | / | / | 0.155 | 0.160 | 0.21 | 0.21 | # |
| 5C1-3 | 1.3 | / | / | 0.126 | 0.148 | 0.179 | 0.22 | # |
| 5C1-4 | - | 2.5,2.7 | 2.2 | 0.174 | 0.25 | 0.21 | 0.44 | # |
| 5C1-5 | - | - | - | - | - | 0.27 | 0.33 | # |
| 5C1-6 | - | - | - | - | - | - | 0.22 | # |
| 5C1-7 | | | | | | | | |
| 5C3-2 | 0.049 | 0.045 | 0.060 | 0.119 | 0.079 | 0.110 | 0.110 | # |
| 5C5-1 | 0.076 | 0.062 | 0.059 | 0.077 | 0.118 | 0.140 | 0.029 | # |
| 5C14-1 | - | 0.174,0.24 | 0.22 | 0.187 | 0.31 | 0.41 | 1.27 | # |
| 5C15-1 | - | - | - | - | - | - | 1.40 | 2.2 |
| 5T1-1 | 0.38 | 0.38 | / | 0.125 | 0.062 | 0.093 | 0.26 | # |
| 5T1-2 | 0.184 | 0.154,0.22 | 0.175 | 0.037 | 0.032 | 0.044 | 0.048 | # |
| 5T2-1 | - | 0.22,0.31 | 0.23 | 0.057 | 0.061 | 0.126 | 0.037 | # |
| 5T2-2 | - | 0.26 | 0.165 | 0.082 | 0.076 | 0.198 | 0.040 | # |
| 5T2-3 | - | - | - | 0.050 | 0.056 | 0.063 | 0.033 | # |
| 5T2-4 | - | - | - | - | - | - | - | # |
| 5T2-5 | - | - | - | - | - | - | - | # |
| 5T2-6 | - | - | - | - | - | - | - | # |
| 5T2-7 | - | - | - | - | - | - | - | # |
| 5T2-8 | - | - | - | - | - | - | - | # |
| 5T3-1 | - | 0.22,0.26 | 0.23 | 0.046 | 0.053 | 0.115 | / | # |
| 5T4-1 | - | 0.170,0.195 | / | 0.032 | 0.028 | 0.035 | 0.099 | # |
| 5T4-2 | - | - | - | 0.073 | 0.048 | 0.064 | -- | # |
| 5T6-1 | - | 0.37,0.42 | 0.34 | 0.047 | 0.043 | 0.116 | / | # |
| 5T7-1 | - | - | - | 0.040 | 0.012 | 0.053 | / | # |

a = antennas not constructed.
b = antennas off, grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 A current.

\- = measurement point not established.
-- = measurement point dropped.
/ = measurement not taken.
# = measurement precluded by antenna operation.

TABLE E-5. 60 Hz MAGNETIC FLUX DENSITIES (mG)
Aquatic Ecosystems Studies

| Site No., Meas. Pt. | 1983[a] | 1984[a] | 1985[a] | 1986[b] | 1987[c] | 1988[c] | 1989[d] | 1990[d] |
|---|---|---|---|---|---|---|---|---|
| 5C1-1 | 0.008 | 0.008 | 0.003 | 0.001 | 0.001 | 0.001 | 0.001 | # |
| 5C1-2 | 0.006 | / | / | 0.001 | 0.001 | <0.001 | 0.001 | # |
| 5C1-3 | 0.004 | / | / | 0.001 | 0.001 | 0.001 | 0.001 | # |
| 5C1-4 | - | 0.007,0.008 | 0.007 | 0.001 | 0.001 | 0.001 | 0.002 | # |
| 5C1-5 | - | - | - | - | - | <0.001 | 0.001 | # |
| 5C1-6 | - | - | - | - | - | - | 0.001 | # |
| 5C1-7 | - | - | - | - | - | - | - | # |
| 5C3-2 | 0.003 | 0.003 | 0.003 | 0.005 | 0.004 | 0.009 | 0.008 | # |
| 5C5-1 | 0.002 | 0.002 | 0.002 | 0.001 | 0.001 | 0.002 | <0.001 | # |
| 5C14-1 | - | 0.013.0.021 | 0.020 | 0.017 | 0.094 | 0.034 | 0.057 | # |
| 5C15-1 | - | - | - | - | - | - | 4.4 | 5.7 |
| 5T1-1 | <0.001 | <0.001 | / | 0.002 | 0.003 | <0.001 | 0.006 | # |
| 5T1-2 | <0.001 | 0.001 | 0.001 | 0.004 | 0.005 | 0.001 | 0.008 | # |
| 5T2-1 | - | 0.001,0.002 | 0.001 | 0.005 | 0.009 | 0.015 | 0.003 | # |
| 5T2-2 | - | 0.002 | 0.001 | 0.014 | 0.021 | 0.047 | 0.009 | # |
| 5T2-3 | - | - | - | 0.004 | 0.007 | 0.007 | 0.003 | # |
| 5T2-4 | - | - | - | - | - | - | - | # |
| 5T2-5 | - | - | - | - | - | - | - | # |
| 5T2-6 | - | - | - | - | - | - | - | # |
| 5T2-7 | - | - | - | - | - | - | - | # |
| 5T2-8 | - | - | - | - | - | - | - | # |
| 5T3-1 | - | 0.001,0.002 | 0.001 | 0.005 | 0.009 | 0.021 | / | # |
| 5T4-1 | - | 0.001 | / | <0.001 | 0.002 | <0.001 | 0.004 | # |
| 5T4-2 | - | - | - | 0.001 | 0.002 | <0.001 | -- | # |
| 5T6-1 | - | 0.001 | 0.001 | 0.001 | 0.002 | 0.003 | / | # |
| 5T7-1 | - | - | - | 0.001 | 0.001 | 0.005 | / | # |

a = antennas not constructed.
b = antennas off, grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 A current.

- = measurement point not established.
-- = measurement point dropped.
/ = measurement not taken.
# = measurement precluded by antenna operation.

TABLE E-6. 76 Hz AIR ELECTRIC FIELD INTENSITIES (V/m)
Aquatic Ecosystems Studies

| Site No., Meas. Pt. | 1986 NS 4 amps | 1986 NEW 6 amps | 1986 SEW 6 amps | 1986 SEW 10 amps (EX) | 1987 NS 15 amps | 1987 EW 15 amps | 1988 NS 75 amps | 1988 EW 75 amps | 1989 B 150 amps | 1990 B 150 amps |
|---|---|---|---|---|---|---|---|---|---|---|
| 5C1-1 | < | < | < | * | < | < | < | < | < | < |
| 5C1-2 | < | < | < | * | < | < | < | < | < | -- |
| 5C1-3 | < | < | < | * | < | < | < | < | < | < |
| 5C1-4 | < | < | < | * | < | < | < | < | < | < |
| 5C1-5 | - | - | - | - | - | - | < | < | < | < |
| 5C1-6 | - | - | - | - | - | - | - | - | < | -- |
| 5C1-7 | | | | | | | | | | |
| 5C3-2 | < | < | < | * | < | < | < | < | < | < |
| 5C5-1 | < | < | < | * | < | < | < | < | < | < |
| 5C14-1 | < | < | < | * | < | < | < | < | < | < |
| 5C15-1 | - | - | - | - | - | - | - | - | # | # |
| 5T1-1 | < | < | < | * | 0.009 | < | 0.037 | 0.001 | 0.091 | -- |
| 5T1-2 | < | < | < | * | <0.001 | < | 0.014 | 0.002 | 0.029 | 0.042 |
| 5T2-1 | 0.001 | < | < | * | 0.005 | < | 0.026 | 0.002 | 0.062 | / |
| 5T2-2 | 0.011 | < | < | * | 0.022 | <0.001 | 0.130 | <0.001 | 0.54 | 0.27 |
| 5T2-3 | < | < | < | * | 0.005 | < | 0.030 | <0.001 | 0.049 | -- |
| 5T2-4 | - | - | - | - | - | - | - | - | - | 9.8 |
| 5T2-5 | - | - | - | - | - | - | - | - | - | 8.3 |
| 5T2-6 | - | - | - | - | - | - | - | - | - | 8.3 |
| 5T2-7 | - | - | - | - | - | - | - | - | - | 6.7 |
| 5T2-8 | - | - | - | - | - | - | - | - | - | 1.08 |
| 5T3-1 | 0.008 | < | < | * | 0.020 | < | 0.104 | <0.001 | 0.175 | 0.24 |
| 5T4-1 | < | < | < | * | 0.003 | < | 0.014 | <0.001 | 0.036 | -- |
| 5T4-2 | < | < | < | * | 0.007 | < | 0.054 | <0.001 | -- | 0.088 |
| 5T6-1 | < | < | < | * | 0.006 | < | 0.035 | 0.002 | 0.057 | -- |
| 5T7-1 | < | < | < | * | / | < | 0.014 | <0.001 | 0.029 | -- |

NS = north-south antenna.
EW = east-west antenna.
NEW = northern EW antenna element.
SEW = southern EW antenna element.
B = NS + EW antennas, standard phasing.
EX = extrapolated data.

- = measurement point not established.
-- = measurement point dropped.
/ = measurement not taken.
< = measurement est. <0.001 based on earth E-field.
* = data cannot be extrapolated.
# = measurement precluded by ambient 60 Hz fields.

TABLE E-7. 76 Hz EARTH ELECTRIC FIELD INTENSITIES (mV/m)
Aquatic Ecosystems Studies

| | 1986 | | | | 1987 | | 1988 | | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|---|
| Site No., Meas. Pt. | NS 4 amps | NEW 6 amps | SEW 6 amps | SEW 10 amps (EX) | NS 15 amps | EW 15 amps | NS 75 amps | EW 75 amps | B 150 amps | B 150 amps |
| 5C1-1 | 0.33 | 0.020 | 0.052 | 0.087 | 1.33 | 0.158 | 6.8 | 0.81 | 11.7 | 12.5 |
| 5C1-2 | 0.24 | 0.016 | 0.053 | 0.088 | 1.07 | 0.186 | 4.9 | 0.76 | 9.9 | -- |
| 5C1-3 | 0.191 | 0.013 | 0.047 | 0.078 | 0.85 | 0.130 | 4.1 | 0.73 | 7.6 | 8.0 |
| 5C1-4 | 0.26 | 0.014 | 0.075 | 0.125 | 1.02 | 0.160 | 4.6 | 0.64 | 10.5 | 10.5 |
| 5C1-5 | - | - | - | - | - | - | 7.1 | 0.83 | 11.9 | 12.3 |
| 5C1-6 | - | - | - | - | - | - | - | - | 7.7 | -- |
| 5C1-7 | - | - | - | - | - | - | - | - | - | 7.9 |
| 5C3-2 | 0.013 | 0.002 | 0.007 | 0.012 | 0.067 | 0.023 | 0.26 | 0.091 | 0.58 | 0.61 |
| 5C5-1 | 0.034 | 0.002 | 0.009 | 0.015 | 0.138 | 0.035 | 0.68 | 0.150 | 1.39 | 1.51 |
| 5C14-1 | 0.042 | 0.004 | 0.015 | 0.025 | 0.183 | 0.055 | 0.81 | 0.25 | 1.86 | 1.70 |
| 5C15-1 | - | - | - | - | - | - | - | - | # | # |
| 5T1-1 | 2.5 | 0.080 | 0.108 | 0.180 | 7.5 | 0.33 | 46 | 1.47 | 98 | -- |
| 5T1-2 | 0.77 | 0.034 | 0.097 | 0.162 | 2.9 | 0.30 | 16.1 | 1.61 | 27 | 32 |
| 5T2-1 | 1.33 | 0.045 | 0.077 | 0.128 | 5.4 | 0.22 | 25 | 1.16 | 47 | 48 |
| 5T2-2 | 1.62 | 0.052 | 0.067 | 0.112 | 6.1 | 0.184 | 31 | 0.100 | 65 | 61 |
| 5T2-3 | 1.17 | 0.042 | 0.079 | 0.132 | 4.9 | 0.23 | 21 | 1.18 | 40 | -- |
| 5T2-4 | - | - | - | - | - | - | - | - | - | 59 |
| 5T2-5 | - | - | - | - | - | - | - | - | - | 61 |
| 5T2-6 | - | - | - | - | - | - | - | - | - | 73 |
| 5T2-7 | - | - | - | - | - | - | - | - | - | 85 |
| 5T2-8 | - | - | - | - | - | - | - | - | - | 95 |
| 5T3-1 | 1.22 | 0.045 | 0.082 | 0.137 | 4.8 | 0.27 | 18.8 | 1.07 | 45 | 42 |
| 5T4-1 | 0.75 | 0.026 | 0.061 | 0.102 | 3.0 | 0.182 | 17.3 | 1.06 | 35 | -- |
| 5T4-2 | 1.91 | 0.056 | 0.077 | 0.128 | 5.3 | 0.21 | 37 | 1.06 | -- | 66 |
| 5T6-1 | 1.21 | 0.030 | 0.066 | 0.110 | 4.5 | 0.20 | 24 | 0.96 | 45 | -- |
| 5T7-1 | 0.76 | 0.033 | 0.072 | 0.120 | 2.6 | 0.189 | 15.3 | 1.09 | 9.4 | -- |

NS = north-south antenna.
EW = east-west antenna.
NEW = northern EW antenna element.
SEW = southern EW antenna element.
B = NS + EW antennas, standard phasing.

EX = extrapolated data.
- = measurement point not established.
-- = measurement point dropped.
/ = data not taken.
# = measurement precluded by ambient 60 Hz fields.

TABLE E-8. 76 Hz MAGNETIC FLUX DENSITIES (mG)
Aquatic Ecosystems Studies

| Site No., Meas. Pt. | 1986 NS 4 amps | 1986 NEW 6 amps | 1986 SEW 6 amps | 1986 SEW 10 amps (EX) | 1987 NS 15 amps | 1987 EW 15 amps | 1988 NS 75 amps | 1988 EW 75 amps | 1989 B 150 amps | 1990 B 150 amps |
|---|---|---|---|---|---|---|---|---|---|---|
| 5C1-1 | 0.001 | <0.001 | <0.001 | * | 0.005 | 0.001 | 0.022 | 0.005 | 0.039 | 0.036 |
| 5C1-2 | 0.001 | <0.001 | <0.001 | * | 0.005 | 0.001 | 0.022 | 0.005 | 0.038 | -- |
| 5C1-3 | 0.001 | <0.001 | <0.001 | * | 0.005 | 0.001 | 0.022 | 0.005 | 0.038 | 0.035 |
| 5C1-4 | 0.001 | <0.001 | <0.001 | * | 0.005 | 0.001 | 0.022 | 0.005 | 0.040 | 0.037 |
| 5C1-5 | - | - | - | - | - | - | 0.022 | 0.005 | 0.038 | 0.035 |
| 5C1-6 | - | - | - | - | - | - | - | - | 0.038 | -- |
| 5C1-7 | - | - | - | - | - | - | - | - | - | 0.035 |
| 5C3-2 | 0.001 | <0.001 | <0.001 | * | 0.003 | 0.001 | 0.016 | 0.004 | 0.038 | 0.037 |
| 5C5-1 | 0.003 | <0.001 | 0.001 | 0.002 | 0.013 | 0.002 | 0.061 | 0.007 | 0.138 | 0.125 |
| 5C14-1 | 0.001 | <0.001 | <0.001 | * | 0.005 | 0.001 | 0.024 | 0.004 | 0.060 | 0.053 |
| 5C15-1 | - | - | - | - | - | - | - | - | # | # |
| 5T1-1 | 0.045 | 0.001 | <0.001 | * | 0.170 | 0.002 | 0.81 | 0.006 | 1.79 | -- |
| 5T1-2 | 0.063 | 0.002 | <0.001 | * | 0.25 | 0.002 | 1.19 | 0.006 | 2.3 | 2.3 |
| 5T2-1 | 0.129 | 0.004 | 0.001 | 0.002 | 0.50 | 0.002 | 2.3 | 0.008 | 4.8 | 4.8 |
| 5T2-2 | 0.31 | 0.009 | 0.001 | 0.002 | 1.20 | 0.003 | 5.5 | 0.018 | 12.7 | 10.6 |
| 5T2-3 | 0.110 | 0.003 | <0.001 | * | 0.41 | 0.002 | 1.90 | 0.007 | 3.7 | -- |
| 5T2-4 | - | - | - | - | - | - | - | - | - | 22 |
| 5T2-5 | - | - | - | - | - | - | - | - | - | 22 |
| 5T2-6 | - | - | - | - | - | - | - | - | - | 22 |
| 5T2-7 | - | - | - | - | - | - | - | - | - | 21 |
| 5T2-8 | - | - | - | - | - | - | - | - | - | 12 |
| 5T3-1 | 0.137 | 0.004 | 0.001 | 0.002 | 0.51 | 0.001 | 2.6 | 0.014 | 5.1 | 4.7 |
| 5T4-1 | 0.028 | 0.001 | <0.001 | * | 0.118 | 0.002 | 0.58 | 0.007 | 1.17 | -- |
| 5T4-2 | 0.033 | 0.001 | <0.001 | * | 0.123 | 0.002 | 0.60 | 0.006 | -- | 1.22 |
| 5T6-1 | 0.029 | 0.001 | 0.001 | 0.002 | 0.109 | 0.002 | 0.51 | 0.008 | 1.03 | -- |
| 5T7-1 | 0.011 | <0.001 | 0.001 | 0.002 | 0.040 | 0.002 | 0.20 | 0.008 | 0.40 | -- |

NS = north-south antenna.
EW = east-west antenna.
NEW = northern EW antenna element.
SEW = southern EW antenna element.
B = NS + EW antennas, standard phasing.

EX = extrapolated data.
\- = measurement point not established.
\-- = measurement point dropped.
/ = data not taken.
* = data cannot be extrapolated.
\# = measurement precluded by ambient 60 Hz fields.

# APPENDIX F

# SOIL AMOEBA STUDIES

## SOIL AMOEBA STUDIES

The objectives of the soil amoeba studies are to monitor population and species characteristics, cell cycle, cropping efficiency, and distribution in the soil. The electric and magnetic fields in the earth are considered the most important electromagnetic (EM) factors to be examined. The electric field in the air is not expected to have a significant impact on the objectives of these studies.

IITRI field crews made ELF EM field measurements at nine measurement points within the two treatment sites and single control site for the soil amoeba studies in 1990. The study sites and the measurement points within those sites were unchanged from 1989. Measurement dates for 1990 and previous years appear in Table F-1.

**TABLE F-1. EM FIELD MEASUREMENT DATES**
**Soil Amoeba Studies**

| Year | Measurement Dates | |
|---|---|---|
| 1983 | Jun 9, 10, 15 | |
| 1984 | May 14 | Aug 10, 13, 15 |
| 1985 | May 6 | Jul 16, 23 |
| 1986 | Oct 3, 10, 16 | |
| 1987 | Sep 30 | Oct 1, 2 |
| 1988 | Sep 20, 23, 27 | Oct 25 |
| 1989 | Sep 11, 18, 20 | |
| 1990 | Sep 27 | Oct 3, 9 |

The positions of the study sites relative to the NRTF-Republic are shown on the composite map in Figure F-1. The site numbers listed on the map are those used by IITRI. Table F-2 provides a cross-reference of IITRI site numbers, investigator site names, and township, range, and section numbers for the sites. Details of measurement locations within sites are shown in Figures F-2 through F-4.

EM field measurements for 1990 and previous years are found in Tables F-3 through F-8. Tables F-3, F-4, and F-5 present 60 Hz data for the air electric field, earth electric field, and magnetic flux density, respectively. Tables F-6, F-7, and F-8 present 76 Hz data for these fields as well as the corresponding operating currents of the NRTF-Republic for each year.

Considerable year-to-year variability in the 60 Hz fields is evident. The primary factors in this variability at treatment sites are changes in power line loading conditions (which are unknown) and differences in the configuration of the antennas at the time of measurement. Notes on the antenna configurations are

**TABLE F-2. SITE NO. CROSS-REFERENCE**
**Soil Amoeba Studies**

| IITRI Site No. | Investigator's Site Name | Location Township | : | Range | : | Section(s) |
|---|---|---|---|---|---|---|
| 6T3 | Leeman's Road | T43N | : | R29W | : | 23 |
| 6T4 | Wells Grade Ground | T42N | : | R29W | : | 2 |
| 6C2 | Merriman Truck Trail Control | T41N | : | R29W | : | 21 |

included in the tables primarily for engineering use. The 60 Hz measurements at treatment sites in 1986, 1987, 1988, and 1990 were taken while the antennas were off, and are representative of 60 Hz levels present during maintenance periods. In 1989, measurements were taken at the ground site during full-power operation of the antennas with an unmodulated signal. These values indicate that 60 Hz EM fields present during operation of the antennas are comparable to those present when the antennas are off.

Annual variations in the 60 Hz EM fields measured at the control study site are also caused by differences in power line loading, but are not dependent on the antennas or their configuration because of the distance of this site from the antennas. The 60 Hz EM field values at the control site, nonetheless, are about as variable as those at the treatment sites.

Overall, the 60 Hz EM fields measured at all study sites in 1990 are consistent with previous field values and with the expected differences in power line loads and the antenna configuration. Regardless of the field variability associated with the measurement condition, 76 Hz EM fields at the treatment sites consistently dominate the 60 Hz EM fields at treatment and control sites, and the ratios of 60 Hz EM fields between matched treatment/control sites continue to meet exposure criteria guidelines established at the beginning of the study.

The 76 Hz EM field measurements in 1990 were made with 150 ampere antenna currents, the predominant operating current of the NRTF-Republic since 4 May 1989. The antenna currents at which measurements were made in each year are given in the column headings of Tables F-6 through F-8. The annual increases in field magnitudes reflect the level of antenna current at the time of measurement: 4 or 6 amperes in 1986, 15 amperes in 1987, 75 amperes in 1988, and 150 amperes in 1989 and 1990. The 1990 measurements are consistent with the 1989 measurements at the same current, and are proportional to the 1986, 1987, and 1988 measurements made at lower currents.

Tables F-9 through F-14 are listings of the data plotted in Figures 29 through 40. The values in the tables represent the daily averages of culture cell current densities and electric field intensities for the 1988, 1989, and 1990 field seasons, as calculated from cell voltage measurements taken by data loggers

at the antenna and ground treatment sites. Daily average computations were based only on the hourly measurements taken when the NS antenna was operating either by itself or simultaneously with the EW antenna. No cell data are listed for days when the NS antenna did not operate (Ant Off); when the culture cells were removed (No Cell); when the data loggers were not installed or not operating (No Logger); or when the amplified cell voltage exceeded the data logger range (Over Range). Accurate cell measurements were not possible at the treatment sites during exclusive operation of the EW antenna, nor at the control site under any conditions, because the cell voltage levels were below the input sensitivity of the data loggers.

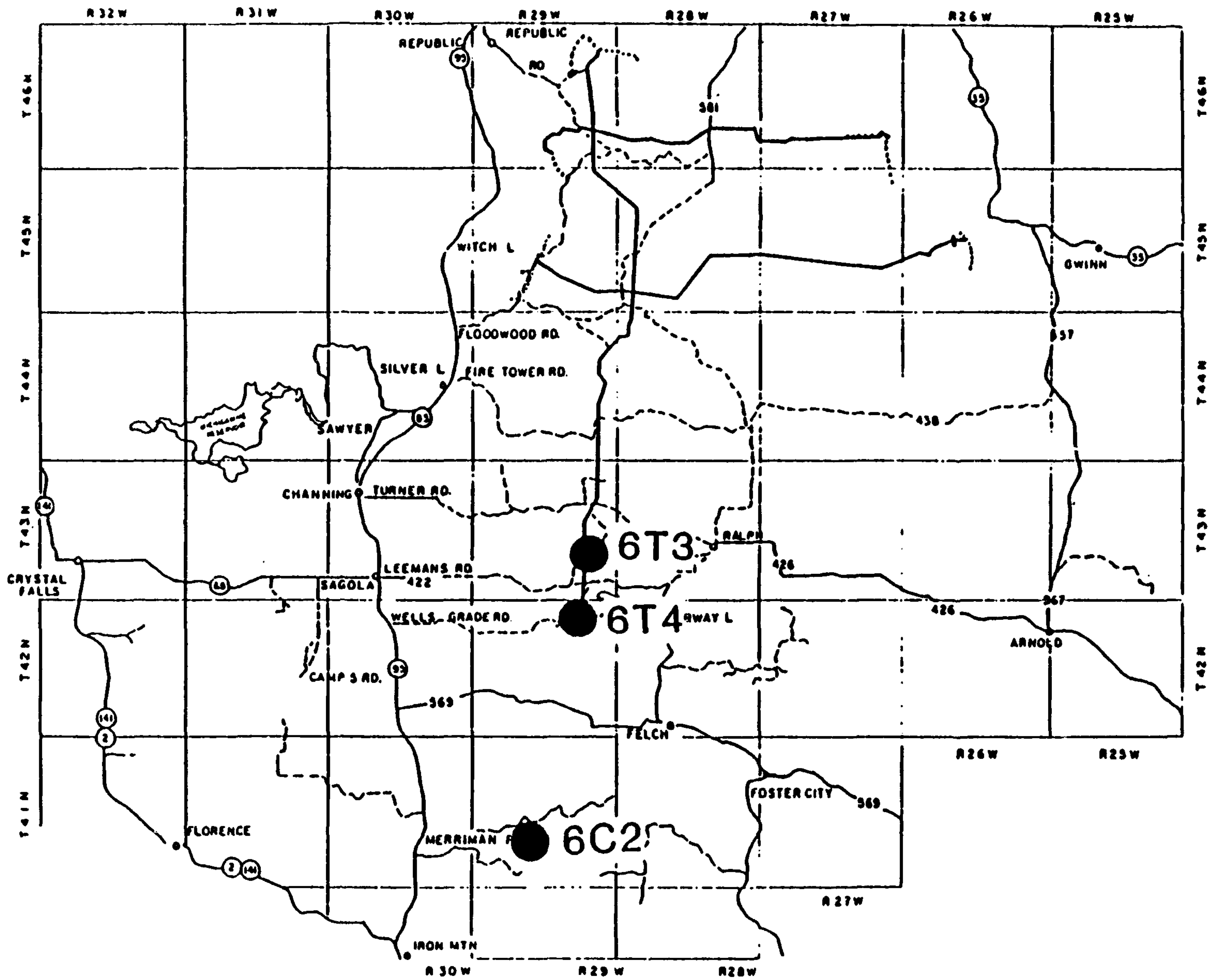



FIGURE F-1. POSITIONS OF SOIL AMOEBA STUDY SITES RELATIVE TO NRTF-REPUBLIC ANTENNA ELEMENTS.

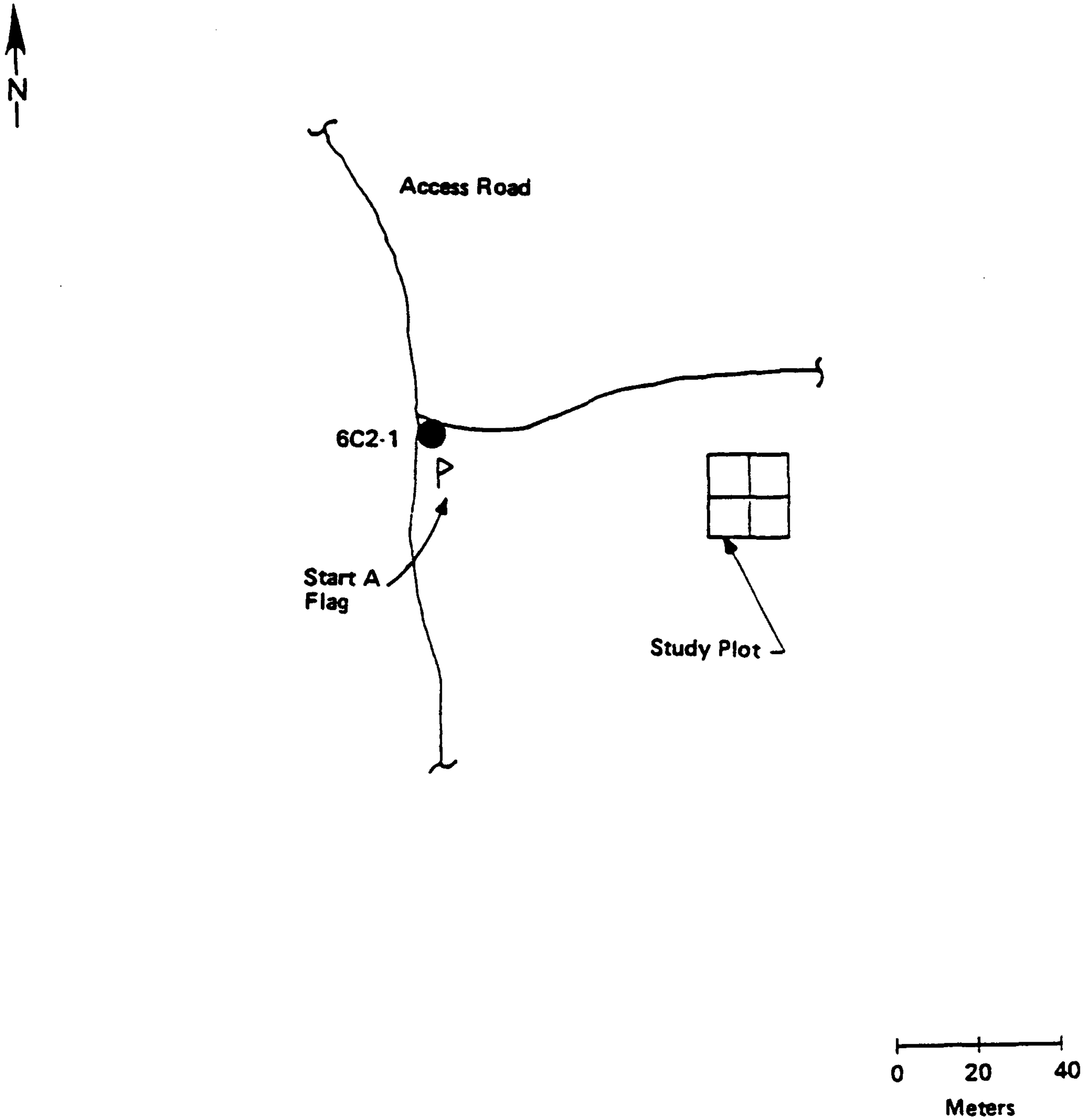



FIGURE F-2. MEASUREMENT POINT AT MERRIMAN TRUCK TRAIL CONTROL; 6C2-1.

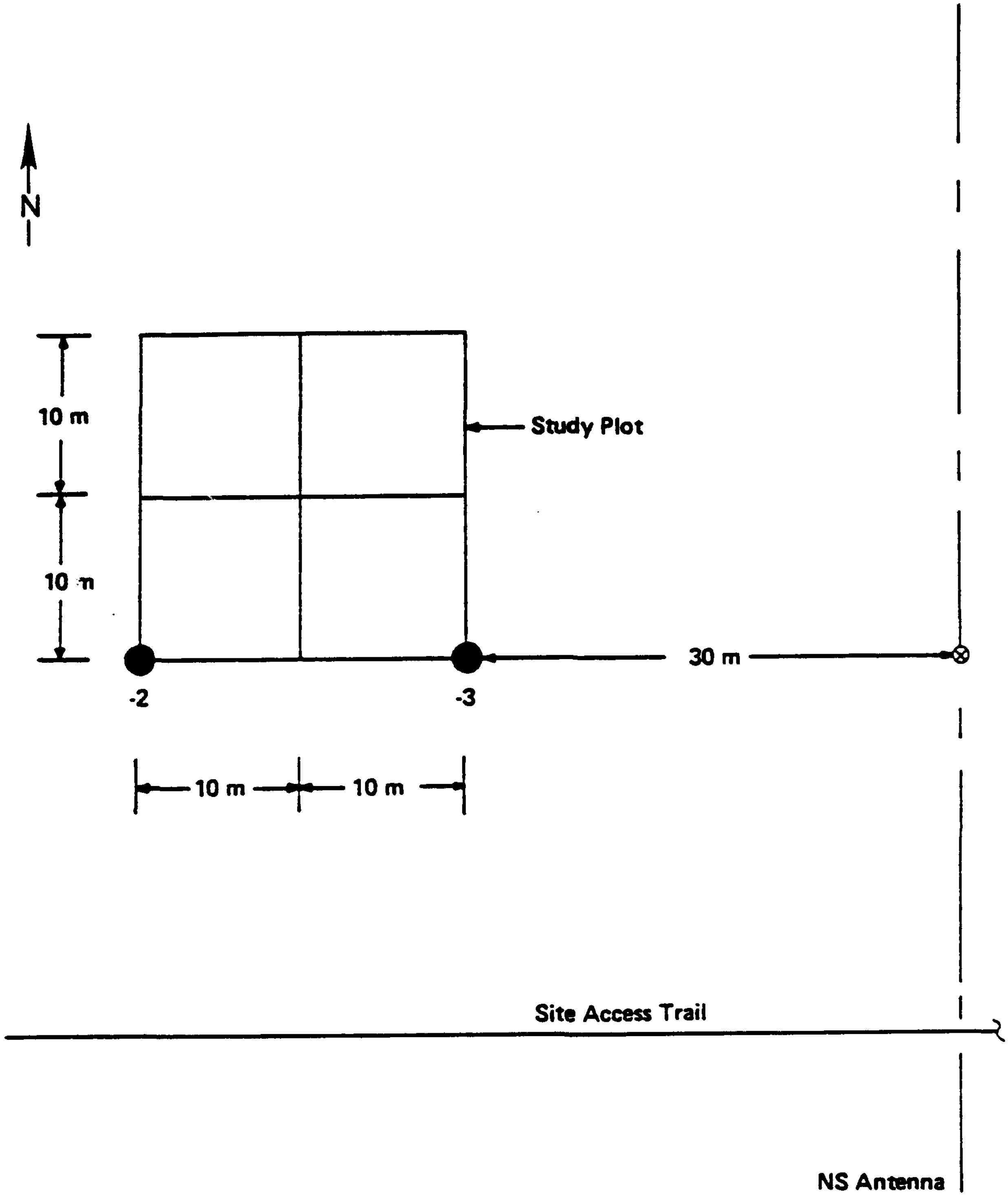



**FIGURE F-3. MEASUREMENT POINTS AT LEEMAN'S ROAD; 6T3-2, 3.**

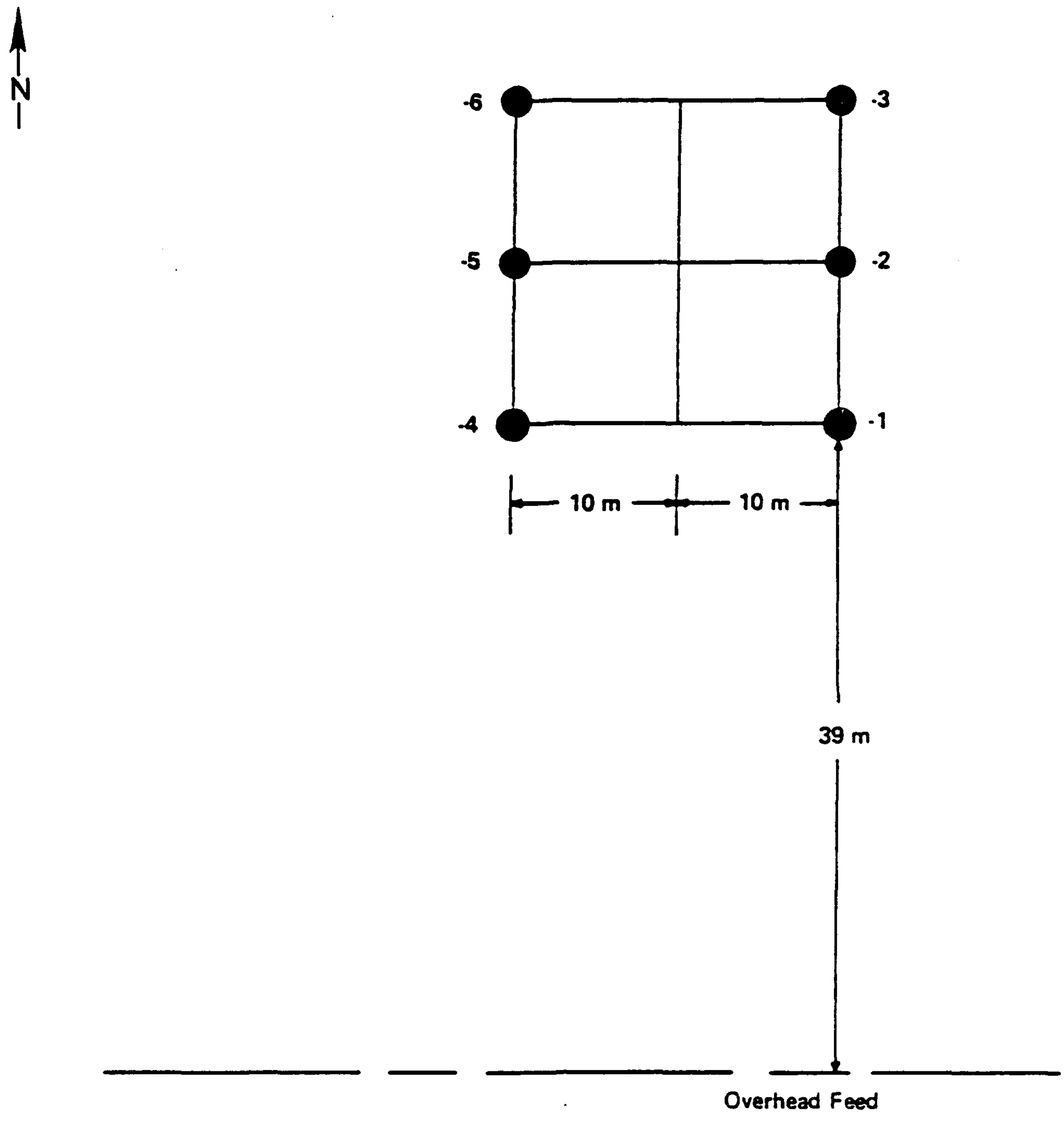



FIGURE F-4. MEASUREMENT POINTS AT WELLS GRADE GROUND; 6T4-1 THROUGH 6.

TABLE F-3. 60 Hz AIR ELECTRIC FIELD INTENSITIES (V/m)
Soil Amoeba Studies

| Site No., Meas. Pt. | 1983[a] | 1984[a] | 1985[a] | 1986[b] | 1987[c] | 1988[c] | 1989[d] | 1990 |
|---|---|---|---|---|---|---|---|---|
| 6C2-1 | <0.001 | < | < | < | < | < | < | (d) |
| 6T3-2 | - | < | < | < | < | < | < | <0.001[c] |
| 6T3-3 | - | - | - | < | < | < | < | (c) |
| 6T4-1 | - | < | < | < | < | < | <0.001 | (b) |
| 6T4-2 | - | - | - | < | < | <0.001 | < | (b) |
| 6T4-3 | - | - | - | < | < | < | < | (b) |
| 6T4-4 | - | - | - | < | < | < | < | (b) |
| 6T4-5 | - | - | - | < | < | < | < | (b) |
| 6T4-6 | - | - | - | < | < | < | < | (b) |

a = antennas not constructed.
b = antennas off, grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 A current.

- = measurement point not established.
< = measurement est. <0.001 V/m based on earth E-field.

TABLE F-4. 60 Hz EARTH ELECTRIC FIELD INTENSITIES (mV/m)
Soil Amoeba Studies

| Site No., Meas. Pt. | 1983[a] | 1984[a] | 1985[a] | 1986[b] | 1987[c] | 1988[c] | 1989[d] | 1990 |
|---|---|---|---|---|---|---|---|---|
| 6C2-1 | 0.32 | 0.61 | 0.194,0.28 | 0.058 | 0.256 | 0.98 | 1.19 | 0.22[d] |
| 6T3-2 | 0.087 | 0.130 | 0.134 | 0.078 | 0.130 | 0.41 | # | 0.193[c] |
| 6T3-3 | - | - | - | 0.085 | 0.125 | 0.35 | # | 0.186[c] |
| 6T4-1 | - | 0.48,0.52 | 0.40 | 0.072 | 0.32 | 0.18 | 0.35 | 0.070[b] |
| 6T4-2 | - | - | - | 0.046 | 0.162 | 0.145 | 0.30 | 0.048[b] |
| 6T4-3 | - | - | - | 0.065 | 0.082 | 0.24 | 0.34 | 0.068[b] |
| 6T4-4 | - | - | - | 0.037 | 0.24 | 0.27 | 0.23 | 0.057[b] |
| 6T4-5 | - | - | - | 0.053 | 0.182 | 0.18 | 0.33 | 0.049[b] |
| 6T4-6 | - | - | - | 0.098 | 0.084 | 0.33 | 0.34 | 0.069[b] |

a = antennas not constructed.
b = antennas off, grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 A current.

\- = measurement point not established.
\# = measurement precluded by antenna operation.

TABLE F-5. 60 Hz MAGNETIC FLUX DENSITIES (mG)
Soil Amoeba Studies

| Site No., Meas. Pt. | 1983[a] | 1984[a] | 1985[a] | 1986[b] | 1987[c] | 1988[c] | 1989[d] | 1990 |
|---|---|---|---|---|---|---|---|---|
| 6C2-1 | 0.004 | 0.008 | 0.001,0.003 | 0.002 | 0.003 | 0.011 | 0.009 | 0.001[d] |
| 6T3-2 | - | 0.002 | 0.003 | 0.013 | 0.033 | 0.103 | # | 0.193[c] |
| 6T3-3 | - | - | - | 0.020 | 0.023 | 0.065 | # | 0.029[c] |
| 6T4-1 | - | 0.005,0.007 | 0.007 | 0.005 | 0.006 | 0.019 | 0.011 | 0.006[b] |
| 6T4-2 | - | - | - | 0.005 | 0.006 | 0.016 | 0.009 | 0.005[b] |
| 6T4-3 | - | - | - | 0.004 | 0.005 | 0.014 | 0.008 | 0.005[b] |
| 6T4-4 | - | - | - | 0.002 | 0.006 | 0.018 | 0.010 | 0.006[b] |
| 6T4-5 | - | - | - | 0.003 | 0.006 | 0.017 | 0.009 | 0.005[b] |
| 6T4-6 | - | - | - | 0.005 | 0.005 | 0.015 | 0.009 | 0.004[b] |

a = antennas not constructed.
b = antennas off, grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 A current.

- = measurement point not established.
# = measurement precluded by antenna operation.

TABLE F-6. 76 Hz AIR ELECTRIC FIELD INTENSITIES (V/m)
Soil Amoeba Studies

| SITE NO., MEAS.PT. | 1986 NS 4 amps | 1986 NEW 6 amps | 1986 SEW 6 amps | 1986 SEW 10 amps (EX) | 1987 NS 15 amps | 1987 EW 15 amps | 1988 NS 75 amps | 1988 EW 75 amps | 1989 B 150 amps | 1990 B 150 amps |
|---|---|---|---|---|---|---|---|---|---|---|
| 6C2-1 | < | < | < | * | < | < | < | < | < | < |
| 6T3-2 | < | < | < | * | 0.005 | < | 0.028 | < | 0.061 | 0.065 |
| 6T3-3 | < | < | < | * | 0.005 | < | 0.027 | < | 0.058 | 0.058 |
| 6T4-1 | < | < | < | * | 0.020 | < | 0.047 | < | 0.036 | 0.056 |
| 6T4-2 | < | < | < | * | 0.007 | < | 0.022 | <0.001 | 0.030 | 0.030 |
| 6T4-3 | < | < | < | * | 0.004 | < | 0.030 | < | 0.045 | 0.041 |
| 6T4-4 | < | < | < | * | 0.014 | < | 0.035 | < | 0.028 | 0.044 |
| 6T4-5 | < | < | < | * | 0.007 | < | 0.036 | <0.001 | 0.047 | 0.033 |
| 6T4-6 | < | < | < | * | 0.004 | < | 0.043 | < | 0.050 | 0.047 |

NS = north-south antenna.
EW = east-west antenna.
NEW = northern EW antenna element.
SEW = southern EW antenna element.
B = NS + EW antennas, standard phasing.
EX = extrapolated data.

< = measurement est. <0.001 V/m based on earth E-field.
* = data cannot be extrapolated.

TABLE F-7. 76 Hz EARTH ELECTRIC FIELD INTENSITIES (mV/m)
Soil Amoeba Studies

| SITE NO., MEAS.PT. | 1986 | | | | 1987 | | 1988 | | 1989 | 1990 |
|---|---|---|---|---|---|---|---|---|---|---|
| | NS 4 amps | NEW 6 amps | SEW 6 amps | SEW 10 amps (EX) | NS 15 amps | EW 15 amps | NS 75 amps | EW 75 amps | B 150 amps | B 150 amps |
| 6C2-1 | 0.028 | 0.010 | 0.011 | 0.018 | 0.068 | 0.028 | 0.36 | 0.140 | 1.37 | 0.76 |
| 6T3-2 | 1.45 | 0.046 | 0.040 | 0.067 | 5.9 | 0.110 | 25 | 0.46 | 54 | 53 |
| 6T3-3 | 1.34 | 0.041 | 0.030 | 0.050 | 5.4 | 0.087 | 21 | 0.47 | 47 | 52 |
| 6T4-1 | 1.73 | 0.059 | 0.007 | 0.012 | 18.9 | 0.056 | 25 | 0.22 | 30 | 48 |
| 6T4-2 | 0.72 | 0.023 | 0.009 | 0.015 | 8.5 | 0.038 | 12.4 | 0.150 | 35 | 28 |
| 6T4-3 | 1.14 | 0.035 | 0.018 | 0.030 | 4.3 | 0.031 | 21 | 0.191 | 49 | 40 |
| 6T4-4 | 1.31 | 0.042 | 0.006 | 0.010 | 12.8 | 0.040 | 21 | 0.174 | 18.4 | 35 |
| 6T4-5 | 0.78 | 0.027 | 0.012 | 0.020 | 10.2 | 0.045 | 15.5 | 0.194 | 33 | 29 |
| 6T4-6 | 1.27 | 0.040 | 0.015 | 0.025 | 4.4 | 0.034 | 26 | 0.22 | 50 | 43 |

NS = north-south antenna.
EW = east-west antenna.
NEW = northern EW antenna element.
SEW = southern EW antenna element.
B = NS + EW antennas, standard phasing.
EX = extrapolated data.

TABLE F-8. 76 Hz MAGNETIC FLUX DENSITIES (mG)
Soil Amoeba Studies

| SITE NO., MEAS.PT. | 1986 NS 4 amps | 1986 NEW 6 amps | 1986 SEW 6 amps | 1986 SEW 10 amps (EX) | 1987 NS 15 amps | 1987 EW 15 amps | 1988 NS 75 amps | 1988 EW 75 amps | 1989 B 150 amps | 1990 B 150 amps |
|---|---|---|---|---|---|---|---|---|---|---|
| 6C2-1 | <0.001 | <0.001 | <0.001 | * | <0.001 | <0.001 | 0.002 | 0.001 | 0.004 | 0.004 |
| 6T3-2 | 0.28 | 0.009 | 0.001 | 0.002 | 1.03 | 0.004 | 4.9 | 0.011 | 10.1 | 10.1 |
| 6T3-3 | 0.170 | 0.006 | 0.001 | 0.002 | 0.64 | 0.003 | 3.1 | 0.007 | 6.3 | 6.2 |
| 6T4-1 | 0.100 | 0.003 | 0.001 | 0.002 | 0.35 | 0.001 | 1.82 | 0.007 | 4.1 | 3.7 |
| 6T4-2 | 0.082 | 0.003 | 0.001 | 0.002 | 0.29 | 0.001 | 1.50 | 0.006 | 3.3 | 3.1 |
| 6T4-3 | 0.071 | 0.002 | <0.001 | * | 0.26 | 0.001 | 1.30 | 0.005 | 2.9 | 2.6 |
| 6T4-4 | 0.090 | 0.003 | 0.001 | 0.002 | 0.38 | 0.001 | 1.64 | 0.006 | 3.8 | 3.3 |
| 6T4-5 | 0.078 | 0.002 | <0.001 | * | 0.27 | <0.001 | 1.41 | 0.006 | 3.4 | 2.8 |
| 6T4-6 | 0.067 | 0.002 | <0.001 | * | 0.24 | 0.001 | 1.22 | 0.005 | 2.7 | 2.4 |

NS = north-south antenna.
EW = east-west antenna.
NEW = northern EW antenna element.
SEW = southern EW antenna element.
B = NS + EW antennas, standard phasing.
EX = extrapolated data.

* = data cannot be extrapolated.

**TABLE F-9. 76 Hz DAILY AVERAGE CULTURE CELL EM EXPOSURES, 1988**
**Soil Amoeba Antenna Study Site (page 1 of 2)**

| Date | Current Density (mA/m²) | | | Electric Field (mV/m) | | |
|---|---|---|---|---|---|---|
| | Cell 1 | Cell 2 | Cell 3 | Cell 4 | Cell 5 | Cell 6 |
| 6-10-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-11-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-12-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-13-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-14-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-15-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-16-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-17-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-18-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-19-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-20-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-21-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-22-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-23-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-24-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-25-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-26-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-27-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-28-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-29-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-30-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-01-88 | 0.02 | 0.01 | 0.01 | 5.13 | 6.02 | 5.58 |
| 7-02-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-03-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-04-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-05-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-06-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-07-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-08-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-09-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-10-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-11-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-12-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-13-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-14-88 | 0.07 | 0.06 | 0.07 | 10.00 | 14.87 | 16.11 |
| 7-15-88 | 0.07 | 0.06 | 0.07 | 28.67 | 53.10 | 32.74 |
| 7-16-88 | 0.07 | 0.06 | 0.07 | 27.61 | 49.56 | 26.28 |
| 7-17-88 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 7-18-88 | 0.04 | 0.04 | 0.04 | 19.82 | 37.96 | 20.97 |
| 7-19-88 | 0.05 | 0.04 | 0.05 | 22.48 | 42.12 | 25.22 |
| 7-20-88 | 0.07 | 0.06 | 0.07 | 30.80 | 54.25 | 33.72 |
| 7-21-88 | 0.07 | 0.06 | 0.07 | 27.26 | 36.81 | 29.56 |
| 7-22-88 | 0.07 | 0.06 | 0.07 | 23.01 | 24.07 | 23.72 |
| 7-23-88 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 7-24-88 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 7-25-88 | 0.07 | 0.06 | 0.07 | 23.98 | 23.27 | 24.25 |
| 7-26-88 | 0.07 | 0.06 | 0.07 | 24.69 | 23.72 | 24.69 |
| 7-27-88 | 0.07 | 0.06 | 0.07 | 22.74 | 23.45 | 23.63 |
| 7-28-88 | 0.07 | 0.06 | 0.07 | 19.29 | 21.33 | 22.21 |

**TABLE F-9. 76 Hz DAILY AVERAGE CULTURE CELL EM EXPOSURES, 1988**
**Soil Amoeba Antenna Study Site (page 2 of 2)**

| Date | Current Density ($mA/m^2$) | | | Electric Field (mV/m) | | |
|---|---|---|---|---|---|---|
| | Cell 1 | Cell 2 | Cell 3 | Cell 4 | Cell 5 | Cell 6 |
| 7-29-88 | 0.07 | 0.06 | 0.07 | 15.40 | 18.32 | 20.18 |
| 7-30-88 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 7-31-88 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 8-01-88 | 0.07 | 0.06 | 0.07 | 12.21 | 15.31 | 16.99 |
| 8-02-88 | 0.07 | 0.06 | 0.07 | 10.97 | 13.89 | 15.75 |
| 8-03-88 | 0.07 | 0.06 | 0.07 | 11.95 | 14.96 | 15.49 |
| 8-04-88 | 0.07 | 0.06 | 0.06 | 18.76 | 19.73 | 19.29 |
| 8-05-88 | 0.07 | 0.05 | 0.07 | 30.71 | 26.02 | 26.19 |
| 8-06-88 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 8-07-88 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 8-08-88 | 0.07 | 0.06 | 0.07 | 30.97 | 26.28 | 25.75 |
| 8-09-88 | 0.07 | 0.06 | 0.07 | 26.64 | 12.30 | 17.88 |
| 8-10-88 | 0.07 | 0.06 | 0.07 | 24.25 | 4.69 | 11.33 |
| 8-11-88 | 0.07 | 0.06 | 0.07 | 10.97 | 17.79 | 12.92 |
| 8-12-88 | 0.07 | 0.06 | 0.07 | 16.90 | 22.39 | 18.41 |
| 8-13-88 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 8-14-88 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 8-15-88 | 0.07 | 0.05 | 0.07 | 26.11 | 30.18 | 34.25 |
| 8-16-88 | 0.07 | 0.05 | 0.07 | 26.28 | 28.67 | 33.45 |
| 8-17-88 | 0.07 | 0.05 | 0.07 | 22.39 | 22.04 | 22.92 |
| 8-18-88 | 0.07 | 0.06 | 0.07 | 26.11 | 26.02 | 26.11 |
| 8-19-88 | 0.07 | 0.06 | 0.07 | 26.02 | 25.93 | 26.02 |
| 8-20-88 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 8-21-88 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 8-22-88 | 0.07 | 0.06 | 0.07 | 24.87 | 24.42 | 25.31 |
| 8-23-88 | 0.07 | 0.06 | 0.07 | 25.49 | 25.40 | 26.02 |
| 8-24-88 | 0.07 | 0.06 | 0.07 | 20.62 | 19.03 | 20.53 |
| 8-25-88 | 0.07 | 0.06 | 0.07 | 8.50 | 4.25 | 7.88 |
| 8-26-88 | 0.07 | 0.06 | 0.07 | 12.30 | 9.03 | 7.88 |
| 8-27-88 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 8-28-88 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 8-29-88 | 0.07 | 0.06 | 0.07 | 26.64 | 26.46 | 8.23 |
| 8-30-88 | 0.07 | 0.06 | 0.07 | 26.19 | 26.11 | 10.27 |
| 8-31-88 | 0.07 | 0.06 | 0.07 | 25.40 | 25.49 | 25.40 |
| 9-01-88 | 0.07 | 0.06 | 0.07 | 25.04 | 24.96 | 24.87 |
| 9-02-88 | 0.07 | 0.06 | 0.07 | 24.78 | 24.42 | 24.34 |
| 9-03-88 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 9-04-88 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 9-05-88 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 9-06-88 | 0.04 | 0.03 | 0.04 | 16.37 | 16.37 | 16.73 |
| 9-07-88 | 0.04 | 0.03 | 0.04 | 15.84 | 15.93 | 16.28 |
| 9-08-88 | 0.04 | 0.03 | 0.04 | 15.84 | 15.75 | 16.02 |
| 9-09-88 | 0.04 | 0.03 | 0.04 | 15.75 | 15.58 | 15.93 |
| 9-10-88 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 9-11-88 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-12-88 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-13-88 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-14-88 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-15-88 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |

**TABLE F-10. 76 Hz DAILY AVERAGE CULTURE CELL EM EXPOSURES, 1989**
**Soil Amoeba Antenna Study Site (page 1 of 2)**

| Date | Current Density (mA/m²) | | | Electric Field (mV/m) | | |
|---|---|---|---|---|---|---|
| | Cell 1 | Cell 2 | Cell 3 | Cell 4 | Cell 5 | Cell 6 |
| 6-10-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 6-11-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 6-12-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 6-13-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 6-14-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 6-15-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 6-16-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 6-17-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 6-18-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 6-19-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 6-20-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 6-21-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 6-22-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 6-23-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 6-24-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 6-25-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 6-26-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 6-27-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 6-28-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 6-29-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 6-30-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 7-01-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 7-02-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 7-03-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 7-04-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 7-05-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 7-06-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 7-07-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 7-08-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 7-09-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 7-10-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 7-11-89 | 0.14 | 0.12 | 0.15 | 60.27 | 64.34 | No Cell |
| 7-12-89 | 0.15 | 0.13 | 0.16 | 59.91 | 72.30 | No Cell |
| 7-13-89 | 0.15 | 0.13 | 0.15 | 55.04 | 52.30 | 53.54 |
| 7-14-89 | 0.15 | 0.13 | 0.16 | 59.12 | 56.19 | 59.73 |
| 7-15-89 | 0.13 | 0.11 | 0.13 | 49.38 | 45.40 | 49.56 |
| 7-16-89 | 0.13 | 0.11 | 0.13 | 46.28 | 36.90 | 45.40 |
| 7-17-89 | 0.15 | 0.14 | 0.15 | 54.25 | 49.03 | 54.60 |
| 7-18-89 | 0.14 | 0.12 | 0.14 | 49.38 | 43.36 | 49.38 |
| 7-19-89 | 0.14 | 0.12 | 0.14 | 48.32 | 41.77 | 48.23 |
| 7-20-89 | 0.14 | 0.12 | 0.14 | 45.75 | 40.35 | 46.37 |
| 7-21-89 | 0.15 | 0.12 | 0.14 | 42.21 | 32.57 | 43.54 |
| 7-22-89 | 0.16 | 0.13 | 0.15 | 40.53 | 30.27 | 42.83 |
| 7-23-89 | 0.12 | 0.10 | 0.11 | 28.94 | 21.68 | 31.77 |
| 7-24-89 | 0.10 | 0.08 | 0.10 | 22.39 | 15.13 | 25.04 |
| 7-25-89 | 0.10 | 0.08 | 0.10 | 20.53 | 13.63 | 23.27 |
| 7-26-89 | 0.09 | 0.08 | 0.09 | 29.12 | 27.52 | 28.85 |
| 7-27-89 | 0.10 | 0.09 | 0.11 | 63.01 | 75.93 | 68.67 |
| 7-28-89 | 0.12 | 0.10 | 0.12 | 72.83 | 77.79 | 80.62 |

**TABLE F-10. 76 Hz DAILY AVERAGE CULTURE CELL EM EXPOSURES, 1989**
**Soil Amoeba Antenna Study Site (page 2 of 2)**

| | Current Density (mA/m$^2$) | | | Electric Field (mV/m) | | |
|---|---|---|---|---|---|---|
| Date | Cell 1 | Cell 2 | Cell 3 | Cell 4 | Cell 5 | Cell 6 |
| 7-29-89 | 0.09 | 0.07 | 0.09 | 75.93 | 83.45 | 60.97 |
| 7-30-89 | 0.12 | 0.10 | 0.12 | 77.88 | Over Range | 81.06 |
| 7-31-89 | 0.14 | 0.12 | 0.14 | 65.93 | Over Range | 91.68 |
| 8-01-89 | 0.11 | 0.10 | 0.12 | 70.44 | 76.64 | 74.42 |
| 8-02-89 | 0.11 | 0.10 | 0.12 | 75.04 | 74.60 | 69.29 |
| 8-03-89 | 0.15 | 0.13 | 0.15 | 107.61 | Over Range | 88.14 |
| 8-04-89 | 0.15 | 0.13 | 0.15 | Over Range | Over Range | 86.73 |
| 8-05-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 8-06-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 8-07-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 8-08-89 | 0.15 | 0.13 | 0.15 | 56.11 | 54.78 | 56.28 |
| 8-09-89 | 0.15 | 0.12 | 0.15 | 51.15 | 50.27 | 51.59 |
| 8-10-89 | 0.14 | 0.12 | 0.14 | 45.93 | 46.37 | 47.61 |
| 8-11-89 | 0.11 | 0.10 | 0.11 | 39.20 | 40.18 | 40.71 |
| 8-12-89 | 0.09 | 0.08 | 0.09 | 39.47 | 40.62 | 39.47 |
| 8-13-89 | 0.09 | 0.08 | 0.09 | 40.00 | 40.88 | 39.29 |
| 8-14-89 | 0.14 | 0.12 | 0.15 | 67.96 | 69.65 | 67.79 |
| 8-15-89 | 0.15 | 0.12 | 0.16 | 71.06 | 71.68 | 70.97 |
| 8-16-89 | 0.14 | 0.12 | 0.15 | 68.32 | 70.00 | 69.20 |
| 8-17-89 | 0.15 | 0.12 | 0.15 | 77.35 | 75.58 | 71.59 |
| 8-18-89 | 0.15 | 0.13 | 0.16 | 100.35 | 74.[illegible]5 | 76.11 |
| 8-19-89 | 0.15 | 0.13 | 0.15 | 91.15 | 53.98 | 70.27 |
| 8-20-89 | 0.15 | 0.13 | 0.15 | 85.22 | 53.45 | 65.75 |
| 8-21-89 | 0.15 | 0.13 | 0.15 | 65.40 | 53.89 | 63.45 |
| 8-22-89 | 0.15 | 0.13 | 0.15 | 66.19 | 53.10 | 61.86 |
| 8-23-89 | 0.14 | 0.12 | 0.14 | 64.78 | 50.35 | 57.70 |
| 8-24-89 | 0.14 | 0.12 | 0.15 | 66.90 | 52.30 | 59.91 |
| 8-25-89 | 0.14 | 0.12 | 0.14 | 65.13 | 51.24 | 58.67 |
| 8-26-89 | 0.11 | 0.09 | 0.11 | 50.62 | 39.20 | 44.87 |
| 8-27-89 | 0.09 | 0.08 | 0.09 | 41.59 | 31.15 | 35.93 |
| 8-28-89 | 0.15 | 0.13 | 0.15 | 63.01 | 48.32 | 55.31 |
| 8-29-89 | 0.15 | 0.13 | 0.15 | 62.48 | 47.79 | 53.89 |
| 8-30-89 | 0.15 | 0.13 | 0.15 | 61.59 | 47.17 | 53.72 |
| 8-31-89 | 0.14 | 0.12 | 0.15 | 68.58 | 55.13 | 65.66 |
| 9-01-89 | 0.14 | 0.12 | 0.15 | 71.50 | 57.61 | 67.88 |
| 9-02-89 | 0.14 | 0.12 | 0.15 | 70.80 | 57.52 | 67.61 |
| 9-03-89 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 9-04-89 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 9-05-89 | 0.14 | 0.12 | 0.15 | 70.09 | 56.99 | 65.75 |
| 9-06-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-07-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-08-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-09-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-10-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-11-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-12-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-13-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-14-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-15-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |

**TABLE F-11. 76 Hz DAILY AVERAGE CULTURE CELL EM EXPOSURES, 1990**
**Soil Amoeba Antenna Study Site (page 1 of 2)**

| | Current Density (mA/m²) | | | Electric Field (mV/m) | | |
|---|---|---|---|---|---|---|
| Date | Cell 1 | Cell 2 | Cell 3 | Cell 4 | Cell 5 | Cell 6 |
| 6-10-90 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-11-90 | 0.14 | 0.13 | 0.15 | 66.11 | 73.01 | 73.54 |
| 6-12-90 | 0.14 | 0.12 | 0.16 | 66.99 | 79.91 | 74.07 |
| 6-13-90 | 0.14 | 0.13 | 0.16 | 64.78 | 77.96 | 59.03 |
| 6-14-90 | 0.13 | 0.13 | 0.15 | 67.35 | 76.90 | 58.67 |
| 6-15-90 | 0.14 | 0.13 | 0.15 | 70.18 | 78.50 | 59.65 |
| 6-16-90 | 0.14 | 0.12 | 0.15 | 75.04 | 82.30 | 63.63 |
| 6-17-90 | 0.14 | 0.12 | 0.16 | 72.04 | 79.47 | 62.92 |
| 6-18-90 | 0.14 | 0.13 | 0.16 | 73.45 | 80.44 | 63.10 |
| 6-19-90 | 0.14 | 0.13 | 0.15 | 75.66 | 80.88 | 64.69 |
| 6-20-90 | 0.14 | 0.13 | 0.15 | 73.10 | 78.76 | 63.01 |
| 6-21-90 | 0.14 | 0.13 | 0.15 | 71.24 | 76.55 | 61.06 |
| 6-22-90 | 0.14 | 0.13 | 0.15 | 73.63 | 78.58 | 61.95 |
| 6-23-90 | 0.14 | 0.13 | 0.15 | 74.87 | 78.67 | 63.45 |
| 6-24-90 | 0.14 | 0.13 | 0.15 | 74.51 | 77.70 | 62.83 |
| 6-25-90 | 0.14 | 0.13 | 0.15 | 70.44 | 73.54 | 59.73 |
| 6-26-90 | 0.14 | 0.13 | 0.15 | 69.29 | 71.77 | 58.41 |
| 6-27-90 | 0.14 | 0.13 | 0.15 | 71.15 | 72.83 | 59.38 |
| 6-28-90 | 0.14 | 0.13 | 0.15 | 71.42 | 73.72 | 59.29 |
| 6-29-90 | 0.14 | 0.13 | 0.15 | 68.67 | 70.97 | 57.43 |
| 6-30-90 | 0.14 | 0.13 | 0.15 | 68.14 | 68.94 | 55.58 |
| 7-01-90 | 0.14 | 0.13 | 0.15 | 68.58 | 69.65 | 54.87 |
| 7-02-90 | 0.14 | 0.13 | 0.15 | 66.64 | 66.37 | 52.65 |
| 7-03-90 | 0.14 | 0.13 | 0.15 | 62.57 | 62.39 | 49.56 |
| 7-04-90 | 0.14 | 0.13 | 0.15 | 61.42 | 59.82 | 46.73 |
| 7-05-90 | 0.15 | 0.13 | 0.15 | 66.73 | 64.96 | 49.20 |
| 7-06-90 | 0.15 | 0.13 | 0.15 | 67.08 | 64.60 | 46.28 |
| 7-07-90 | 0.15 | 0.13 | 0.15 | 67.61 | 65.93 | 48.58 |
| 7-08-90 | 0.13 | 0.13 | 0.15 | 67.35 | 73.36 | 58.76 |
| 7-09-90 | 0.13 | 0.13 | 0.15 | 68.67 | 75.66 | 60.71 |
| 7-10-90 | 0.13 | 0.12 | 0.15 | 65.40 | 70.35 | 61.59 |
| 7-11-90 | 0.14 | 0.13 | 0.15 | 60.80 | 60.88 | 58.41 |
| 7-12-90 | 0.14 | 0.13 | 0.15 | 57.96 | 56.55 | 48.85 |
| 7-13-90 | 0.14 | 0.13 | 0.15 | 57.79 | 55.66 | 54.07 |
| 7-14-90 | 0.14 | 0.13 | 0.15 | 57.52 | 54.96 | 62.30 |
| 7-15-90 | 0.14 | 0.13 | 0.15 | 56.90 | 55.31 | 61.95 |
| 7-16-90 | 0.14 | 0.13 | 0.15 | 55.13 | 53.54 | 60.00 |
| 7-17-90 | 0.14 | 0.13 | 0.15 | 55.84 | 53.54 | 64.60 |
| 7-18-90 | 0.14 | 0.13 | 0.15 | 53.36 | 50.18 | 60.09 |
| 7-19-90 | 0.14 | 0.13 | 0.15 | 56.55 | 52.74 | 64.34 |
| 7-20-90 | 0.14 | 0.13 | 0.15 | 56.02 | 53.10 | 65.22 |
| 7-21-90 | 0.14 | 0.13 | 0.15 | 54.96 | 51.50 | 58.94 |
| 7-22-90 | 0.14 | 0.13 | 0.15 | 56.02 | 52.21 | 57.61 |
| 7-23-90 | 0.14 | 0.13 | 0.15 | 56.46 | 53.72 | 60.53 |
| 7-24-90 | 0.14 | 0.13 | 0.15 | 53.19 | 50.88 | 54.69 |
| 7-25-90 | 0.14 | 0.13 | 0.15 | 50.18 | 47.61 | 44.87 |
| 7-26-90 | 0.14 | 0.13 | 0.15 | 47.17 | 44.16 | 35.31 |
| 7-27-90 | 0.15 | 0.13 | 0.14 | 45.58 | 42.21 | 32.57 |
| 7-28-90 | 0.15 | 0.13 | 0.15 | 47.35 | 43.72 | 39.29 |

TABLE F-11. 76 Hz DAILY AVERAGE CULTURE CELL EM EXPOSURES, 1990
Soil Amoeba Antenna Study Site (page 2 of 2)

| Date | Current Density ($mA/m^2$) | | | Electric Field (mV/m) | | |
|---|---|---|---|---|---|---|
| | Cell 1 | Cell 2 | Cell 3 | Cell 4 | Cell 5 | Cell 6 |
| 7-29-90 | 0.14 | 0.13 | 0.15 | 50.88 | 49.12 | 56.19 |
| 7-30-90 | 0.14 | 0.13 | 0.15 | 57.17 | 57.08 | 66.55 |
| 7-31-90 | 0.14 | 0.13 | 0.15 | 58.76 | 60.53 | 72.12 |
| 8-01-90 | 0.15 | 0.13 | 0.15 | 53.27 | 58.50 | 69.38 |
| 8-02-90 | 0.15 | 0.13 | 0.15 | 50.80 | 61.15 | 59.38 |
| 8-03-90 | 0.15 | 0.13 | 0.15 | 50.62 | 61.59 | 51.95 |
| 8-04-90 | 0.14 | 0.13 | 0.15 | 54.25 | 70.27 | 74.78 |
| 8-05-90 | 0.14 | 0.13 | 0.15 | 62.57 | 83.89 | 106.90 |
| 8-06-90 | 0.14 | 0.13 | 0.15 | 62.57 | 80.09 | 87.79 |
| 8-07-90 | 0.14 | 0.13 | 0.15 | 54.69 | 67.96 | 56.11 |
| 8-08-90 | 0.14 | 0.13 | 0.15 | 49.38 | 58.05 | 58.67 |
| 8-09-90 | 0.15 | 0.13 | 0.15 | 46.11 | 50.88 | 47.61 |
| 8-10-90 | 0.15 | 0.13 | 0.15 | 46.64 | 52.83 | 47.17 |
| 8-11-90 | 0.15 | 0.13 | 0.15 | 53.27 | 62.65 | 72.30 |
| 8-12-90 | 0.14 | 0.13 | 0.15 | 59.73 | 75.58 | 91.95 |
| 8-13-90 | 0.14 | 0.13 | 0.15 | 58.05 | 73.45 | 82.83 |
| 8-14-90 | 0.14 | 0.13 | 0.14 | 51.33 | 66.02 | 84.16 |
| 8-15-90 | 0.14 | 0.13 | 0.15 | 51.15 | 68.41 | 86.90 |
| 8-16-90 | 0.15 | 0.14 | 0.14 | 46.37 | 56.11 | 66.19 |
| 8-17-90 | 0.15 | 0.13 | 0.15 | 43.19 | 50.18 | 47.43 |
| 8-18-90 | 0.14 | 0.14 | 0.15 | 58.05 | 77.35 | 50.09 |
| 8-19-90 | 0.14 | 0.14 | 0.15 | 69.03 | 95.31 | Over Range |
| 8-20-90 | 0.14 | 0.13 | 0.15 | 67.61 | 92.83 | Over Range |
| 8-21-90 | 0.14 | 0.13 | 0.15 | 64.07 | 88.32 | Over Range |
| 8-22-90 | 0.14 | 0.13 | 0.15 | 63.01 | 83.89 | 120.97 |
| 8-23-90 | 0.15 | 0.13 | 0.15 | 60.18 | 80.35 | 119.91 |
| 8-24-90 | 0.15 | 0.13 | 0.15 | 57.61 | 74.96 | 106.90 |
| 8-25-90 | 0.14 | 0.13 | 0.15 | 58.32 | 76.19 | 116.99 |
| 8-26-90 | 0.14 | 0.13 | 0.15 | 60.53 | 80.88 | 138.94 |
| 8-27-90 | 0.14 | 0.13 | 0.14 | 61.33 | 82.04 | 127.70 |
| 8-28-90 | 0.14 | 0.13 | 0.15 | 59.65 | 77.52 | 92.83 |
| 8-29-90 | 0.15 | 0.13 | 0.15 | 59.73 | 72.92 | 80.62 |
| 8-30-90 | 0.15 | 0.13 | 0.15 | 54.25 | 62.04 | 62.57 |
| 8-31-90 | 0.15 | 0.13 | 0.15 | 54.42 | 64.25 | 60.80 |
| 9-01-90 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-02-90 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-03-90 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-04-90 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-05-90 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-06-90 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-07-90 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-08-90 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-09-90 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-10-90 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-11-90 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-12-90 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-13-90 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-14-90 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-15-90 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |

**TABLE F-12. 76 Hz DAILY AVERAGE CULTURE CELL EM EXPOSURES, 1988**
**Soil Amoeba Ground Study Site (page 1 of 2)**

| Date | Current Density ($mA/m^2$) | | | Electric Field (mV/m) | | |
|---|---|---|---|---|---|---|
| | Cell 1 | Cell 2 | Cell 3 | Cell 4 | Cell 5 | Cell 6 |
| 6-10-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-11-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-12-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-13-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-14-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-15-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-16-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-17-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-18-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-19-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-20-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-21-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-22-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-23-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-24-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-25-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-26-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-27-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-28-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-29-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-30-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-01-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-02-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-03-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-04-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-05-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-06-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-07-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-08-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-09-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-10-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-11-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-12-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-13-88 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-14-88 | 0.06 | 0.06 | 0.07 | 6.02 | 15.04 | 13.10 |
| 7-15-88 | 0.05 | 0.06 | 0.06 | 13.45 | 26.90 | 18.58 |
| 7-16-88 | 0.05 | 0.05 | 0.06 | 15.31 | 30.35 | 18.76 |
| 7-17-88 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 7-18-88 | 0.05 | 0.05 | 0.06 | 15.66 | 30.35 | 19.12 |
| 7-19-88 | 0.05 | 0.05 | 0.06 | 14.34 | 28.23 | 18 41 |
| 7-20-88 | 0.05 | 0.06 | 0.07 | 16.02 | 30.97 | 19.82 |
| 7-21-88 | 0.06 | 0.06 | 0.07 | 23.10 | 29.20 | 24.42 |
| 7-22-88 | 0.06 | 0.06 | 0.07 | 20.09 | 21.50 | 21.68 |
| 7-23-88 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 7-24-88 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 7-25-88 | 0.04 | 0.04 | 0.05 | 11.24 | 12.12 | 14.51 |
| 7-26-88 | 0.04 | 0.04 | 0.05 | 10.18 | 11.95 | 14.51 |
| 7-27-88 | 0.04 | 0.04 | 0.05 | 9.29 | 11.42 | 13.98 |
| 7-28-88 | 0.04 | 0.04 | 0.05 | 7.26 | 10.09 | 12.57 |

**TABLE F-12. 76 Hz DAILY AVERAGE CULTURE CELL EM EXPOSURES, 1988**
**Soil Amoeba Ground Study Site (page 2 of 2)**

| | Current Density ($mA/m^2$) | | | Electric Field (mV/m) | | |
|---|---|---|---|---|---|---|
| Date | Cell 1 | Cell 2 | Cell 3 | Cell 4 | Cell 5 | Cell 6 |
| 7-29-88 | 0.04 | 0.04 | 0.05 | 5.22 | 8.76 | 11.86 |
| 7-30-88 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 7-31-88 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 8-01-88 | 0.04 | 0.04 | 0.05 | 4.60 | 7.88 | 11.15 |
| 8-02-88 | 0.04 | 0.04 | 0.05 | 3.89 | 7.70 | 11.15 |
| 8-03-88 | 0.04 | 0.04 | No Cell | 8.32 | 13.63 | 15.13 |
| 8-04-88 | 0.04 | 0.04 | 0.05 | 12.74 | 17.88 | 22.12 |
| 8-05-88 | 0.04 | 0.04 | 0.05 | 18.85 | 21.50 | 19.29 |
| 8-06-88 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 8-07-88 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 8-08-88 | 0.04 | 0.04 | 0.05 | 11.95 | 15.04 | 17.08 |
| 8-09-88 | 0.04 | 0.04 | 0.05 | 12.04 | 15.40 | 20.18 |
| 8-10-88 | 0.04 | 0.04 | 0.05 | 8.50 | 13.98 | 24.25 |
| 8-11-88 | 0.04 | 0.04 | 0.05 | 8.14 | 9.47 | 12.21 |
| 8-12-88 | 0.04 | 0.04 | 0.05 | 8.41 | 10.18 | 12.48 |
| 8-13-88 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 8-14-88 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 8-15-88 | 0.04 | 0.04 | 0.04 | 22.65 | 23.19 | 19.56 |
| 8-16-88 | 0.04 | 0.04 | 0.04 | 16.81 | 17.17 | 17.52 |
| 8-17-88 | 0.04 | 0.04 | 0.04 | 23.81 | 22.83 | 20.71 |
| 8-18-88 | 0.04 | 0.04 | 0.04 | 23.45 | 23.45 | 23.36 |
| 8-19-88 | 0.04 | 0.04 | 0.04 | 23.27 | 23.19 | 23.19 |
| 8-20-88 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 8-21-88 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 8-22-88 | 0.04 | 0.04 | 0.04 | 20.88 | 20.62 | 21.33 |
| 8-23-88 | 0.04 | 0.04 | 0.04 | 22.30 | 22.04 | 22.39 |
| 8-24-88 | 0.04 | 0.04 | 0.04 | 22.12 | 22.12 | 22.57 |
| 8-25-88 | 0.04 | 0.04 | 0.04 | 23.27 | 23.89 | 24.07 |
| 8-26-88 | 0.04 | 0.04 | 0.04 | 22.65 | 23.19 | 23.54 |
| 8-27-88 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 8-28-88 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 8-29-88 | 0.04 | 0.04 | 0.04 | 22.92 | 23.36 | 23.81 |
| 8-30-88 | 0.04 | 0.04 | 0.04 | 22.83 | 23.27 | 23.72 |
| 8-31-88 | 0.04 | 0.04 | 0.04 | 22.65 | 22.74 | 23.19 |
| 9-01-88 | 0.04 | 0.04 | 0.04 | 22.48 | 22.83 | 22.74 |
| 9-02-88 | 0.04 | 0.04 | 0.04 | 21.50 | 21.95 | 22.04 |
| 9-03-88 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 9-04-88 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 9-05-88 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 9-06-88 | 0.03 | 0.03 | 0.03 | 19.91 | 19.29 | 20.62 |
| 9-07-88 | 0.03 | 0.03 | 0.03 | 19.20 | 18.41 | 19.82 |
| 9-08-88 | 0.03 | 0.03 | 0.03 | 18.50 | 17.96 | 19.38 |
| 9-09-88 | 0.03 | 0.03 | 0.03 | 18.14 | 17.61 | 19.12 |
| 9-10-88 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 9-11-88 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-12-88 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-13-88 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-14-88 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-15-88 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |

## TABLE F-13. 76 Hz DAILY AVERAGE CULTURE CELL EM EXPOSURES, 1989
### Soil Amoeba Ground Study Site (page 1 of 2)

| Date | Current Density (mA/m²) Cell 1 | Cell 2 | Cell 3 | Electric Field (mV/m) Cell 4 | Cell 5 | Cell 6 |
|---|---|---|---|---|---|---|
| 6-10-89 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-11-89 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-12-89 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-13-89 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-14-89 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-15-89 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-16-89 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-17-89 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-18-89 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-19-89 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-20-89 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-21-89 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-22-89 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-23-89 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-24-89 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-25-89 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-26-89 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-27-89 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-28-89 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-29-89 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-30-89 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-01-89 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-02-89 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-03-89 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-04-89 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-05-89 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-06-89 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-07-89 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-08-89 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-09-89 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-10-89 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-11-89 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 7-12-89 | 0.05 | 0.05 | 0.05 | 18.14 | 18.14 | 25.84 |
| 7-13-89 | 0.05 | 0.05 | 0.06 | 20.35 | 19.73 | 27.26 |
| 7-14-89 | 0.05 | 0.05 | 0.05 | 20.88 | 20.09 | 28.85 |
| 7-15-89 | 0 06 | 0.06 | 0.07 | 26.37 | 24.51 | 32.92 |
| 7-16-89 | 0.07 | 0.06 | 0.07 | 26.99 | 25.13 | 33.98 |
| 7-17-89 | 0.06 | 0.06 | 0.07 | 23.89 | 23.98 | 31.50 |
| 7-18-89 | 0.06 | 0.07 | 0.07 | 25.49 | 25.84 | 33.27 |
| 7-19-89 | 0.06 | 0.06 | 0.07 | 24.69 | 25.13 | 32.83 |
| 7-20-89 | 0.06 | 0.06 | 0.07 | 25.31 | 24.51 | 32.39 |
| 7-21-89 | 0.07 | 0.07 | 0.07 | 23.81 | 23.63 | 32.48 |
| 7-22-89 | 0.06 | 0.06 | 0.07 | 20.62 | 19.56 | 28.94 |
| 7-23-89 | 0.08 | 0.08 | 0.09 | 27.79 | 26.64 | 34.07 |
| 7-24-89 | 0.09 | 0.08 | 0.10 | 30.00 | 28.76 | 37.70 |
| 7-25-89 | 0.09 | 0.08 | 0.10 | 28.67 | 26.46 | 35.58 |
| 7-26-89 | 0.09 | 0.08 | 0.10 | 30.18 | 27.52 | 36.28 |
| 7-27-89 | 0.09 | 0.08 | 0.09 | 40.00 | 39.12 | 37.43 |
| 7-28-89 | 0.08 | 0.07 | 0.09 | 39.38 | 38.50 | 35.31 |

**TABLE F-13. 76 Hz DAILY AVERAGE CULTURE CELL EM EXPOSURES, 1989**
**Soil Amoeba Ground Study Site (page 2 of 2)**

| Date | Current Density ($mA/m^2$) | | | Electric Field (mV/m) | | |
|---|---|---|---|---|---|---|
| | Cell 1 | Cell 2 | Cell 3 | Cell 4 | Cell 5 | Cell 6 |
| 7-29-89 | 0.09 | 0.08 | 0.09 | 47.17 | 44.69 | 40.09 |
| 7-30-89 | 0.08 | 0.08 | 0.09 | 42.92 | 41.06 | 38.94 |
| 7-31-89 | 0.07 | 0.07 | 0.08 | 34.69 | 33.36 | 32.74 |
| 8-01-89 | 0.08 | 0.07 | 0.09 | 38.85 | 36.99 | 33.63 |
| 8-02-89 | 0.08 | 0.07 | 0.08 | 34.16 | 32.74 | 32.04 |
| 8-03-89 | 0.06 | 0.06 | 0.07 | 25.66 | 24.42 | 25.31 |
| 8-04-89 | 0.06 | 0.06 | 0.06 | 23.10 | 22.21 | 23.36 |
| 8-05-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 8-06-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 8-07-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 8-08-89 | 0.07 | 0.06 | 0.07 | 23.10 | 14.07 | 19.38 |
| 8-09-89 | 0.07 | 0.07 | 0.08 | 24.16 | 16.81 | 21.77 |
| 8-10-89 | 0.07 | 0.07 | 0.08 | 25.49 | 23.36 | 24.25 |
| 8-11-89 | 0.09 | 0.08 | 0.10 | 38.85 | 40.18 | 36.02 |
| 8-12-89 | 0.10 | 0.09 | 0.10 | 61.06 | 59.91 | 53.63 |
| 8-13-89 | 0.10 | 0.09 | 0.10 | 65.84 | 64.96 | 55.31 |
| 8-14-89 | 0.07 | 0.07 | 0.07 | 47.35 | 45.66 | 41.06 |
| 8-15-89 | 0.07 | 0.06 | 0.07 | 44.34 | 44.42 | 38.85 |
| 8-16-89 | 0.06 | 0.06 | 0.07 | 41.68 | 42.65 | 36.55 |
| 8-17-89 | 0.07 | 0.06 | 0.07 | 47.52 | 47.43 | 38.76 |
| 8-18-89 | 0.07 | 0.07 | 0.07 | 83.01 | 101.06 | 37.52 |
| 8-19-89 | 0.07 | 0.07 | 0.08 | 90.62 | Over Range | 27.26 |
| 8-20-89 | 0.07 | 0.07 | 0.07 | 90.00 | Over Range | 27.61 |
| 8-21-89 | 0.07 | 0.07 | 0.07 | 51.86 | 38.23 | 28.05 |
| 8-22-89 | 0.07 | 0.07 | 0.07 | 25.93 | 40.62 | 26.19 |
| 8-23-89 | 0.07 | 0.07 | 0.08 | 28.67 | 47.35 | 28.85 |
| 8-24-89 | 0.07 | 0.07 | 0.07 | 28.67 | 44.07 | 28.58 |
| 8-25-89 | 0.07 | 0.07 | 0.08 | 30.00 | 47.96 | 30.71 |
| 8-26-89 | 0.09 | 0.08 | 0.09 | 39.03 | 58.94 | 37.35 |
| 8-27-89 | 0.10 | 0.09 | 0.10 | 43.01 | 65.31 | 41.68 |
| 8-28-89 | 0.07 | 0.07 | 0.08 | 26.73 | 42.57 | 28.32 |
| 8-29-89 | 0.07 | 0.07 | 0.07 | 24.07 | 37.79 | 25.49 |
| 8-30-89 | 0.07 | 0.06 | 0.07 | 23.10 | 34.96 | 24.78 |
| 8-31-89 | 0.06 | 0.06 | 0.07 | 27.43 | 46.11 | 26.19 |
| 9-01-89 | 0.06 | 0.06 | 0.07 | 29.47 | 48.41 | 27.17 |
| 9-02-89 | 0.07 | 0.07 | 0.07 | 30.97 | 53.98 | 29.82 |
| 9-03-89 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 9-04-89 | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off | Ant Off |
| 9-05-89 | 0.06 | 0.06 | 0.07 | 28.23 | 46.55 | 26.28 |
| 9-06-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-07-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-08-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-09-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-10-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-11-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-12-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-13-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-14-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-15-89 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |

**TABLE F-14. 76 Hz DAILY AVERAGE CULTURE CELL EM EXPOSURES, 1990**
**Soil Amoeba Ground Study Site (page 1 of 2)**

| | Current Density (mA/m²) | | | Electric Field (mV/m) | | |
|---|---|---|---|---|---|---|
| Date | Cell 1 | Cell 2 | Cell 3 | Cell 4 | Cell 5 | Cell 6 |
| 6-10-90 | No Logger | No Logger | No Logger | No Logger | No Logger | No Logger |
| 6-11-90 | 0.05 | 0.04 | 0.06 | 37.43 | 37.96 | 35.66 |
| 6-12-90 | 0.05 | 0.04 | 0.06 | 33.89 | 37.35 | 33.98 |
| 6-13-90 | 0.05 | 0.03 | 0.06 | 26.02 | 31.24 | 32.83 |
| 6-14-90 | 0.05 | 0.03 | 0.06 | 26.28 | 29.56 | 33.89 |
| 6-15-90 | 0.05 | 0.03 | 0.06 | 26.64 | 31.06 | 35.13 |
| 6-16-90 | 0.05 | 0.02 | 0.06 | 29.47 | 33.89 | 35.93 |
| 6-17-90 | 0.05 | 0.02 | 0.06 | 27.96 | 33.98 | 36.99 |
| 6-18-90 | 0.05 | 0.02 | 0.06 | 29.56 | 34.69 | 34.78 |
| 6-19-90 | 0.05 | 0.03 | 0.06 | 29.65 | 35.31 | 34.87 |
| 6-20-90 | 0.05 | 0.03 | 0.06 | 28.58 | 33.36 | 34.69 |
| 6-21-90 | 0.05 | 0.03 | 0.06 | 28.41 | 31.59 | 32.92 |
| 6-22-90 | 0.05 | 0.03 | 0.06 | 27.43 | 32.30 | 32.92 |
| 6-23-90 | 0.05 | 0.03 | 0.06 | 28.05 | 32.12 | 36.02 |
| 6-24-90 | 0.05 | 0.03 | 0.06 | 27.70 | 30.88 | 32.48 |
| 6-25-90 | 0.05 | 0.04 | 0.06 | 25.31 | 29.12 | 32.30 |
| 6-26-90 | 0.05 | 0.04 | 0.06 | 24.16 | 28.41 | 32.48 |
| 6-27-90 | 0.05 | 0.04 | 0.06 | 26.02 | 29.29 | 31.24 |
| 6-28-90 | 0.05 | 0.04 | 0.06 | 24.78 | 28.41 | 31.86 |
| 6-29-90 | 0.05 | 0.04 | 0.06 | 25.75 | 28.23 | 31.15 |
| 6-30-90 | 0.05 | 0.04 | 0.06 | 24.25 | 27.17 | 31.68 |
| 7-01-90 | 0.05 | 0.04 | 0.06 | 25.04 | 28.14 | 30.97 |
| 7-02-90 | 0.05 | 0.05 | 0.06 | 23.45 | 26.37 | 30.53 |
| 7-03-90 | 0.05 | 0.05 | 0.06 | 22.48 | 24.51 | 28.14 |
| 7-04-90 | 0.05 | 0.05 | 0.06 | 21.95 | 25.75 | 28.23 |
| 7-05-90 | 0.06 | 0.05 | 0.06 | 22.92 | 26.37 | 30.71 |
| 7-06-90 | 0.05 | 0.06 | 0.06 | 23.10 | 26.90 | 28.14 |
| 7-07-90 | 0.05 | 0.06 | 0.06 | 23.27 | 26.19 | 29.82 |
| 7-08-90 | 0.05 | 0.05 | 0.06 | 24.16 | 28.23 | 34.25 |
| 7-09-90 | 0.05 | 0.04 | 0.06 | 23.36 | 29.73 | 33.63 |
| 7-10-90 | 0.05 | 0.05 | 0.06 | 30.97 | 27.35 | 31.42 |
| 7-11-90 | 0.06 | 0.06 | 0.06 | 32.21 | 25.31 | 30.18 |
| 7-12-90 | 0.06 | 0.06 | 0.06 | 32.74 | 25.75 | 29.65 |
| 7-13-90 | 0.06 | 0.06 | 0.06 | 30.53 | 26.02 | 30.53 |
| 7-14-90 | 0.06 | 0.06 | 0.06 | 30.27 | 25.93 | 29.12 |
| 7-15-90 | 0.06 | 0.06 | 0.06 | 29.47 | 26.46 | 30.80 |
| 7-16-90 | 0.06 | 0.06 | 0.06 | 29.29 | 26.81 | 30.71 |
| 7-17-90 | 0.06 | 0.06 | 0.06 | 33.19 | 28.94 | 33.98 |
| 7-18-90 | 0.06 | 0.06 | 0.06 | 31.95 | 26.73 | 33.27 |
| 7-19-90 | 0.05 | 0.06 | 0.06 | 32.48 | 26.28 | 33.89 |
| 7-20-90 | 0.06 | 0.06 | 0.06 | 32.30 | 26.64 | 32.74 |
| 7-21-90 | 0.06 | 0.06 | 0.06 | 31.95 | 26.64 | 31.86 |
| 7-22-90 | 0.06 | 0.06 | 0.06 | 32.12 | 28.32 | 32.83 |
| 7-23-90 | 0.06 | 0.06 | 0.06 | 33.01 | 27.61 | 32.12 |
| 7-24-90 | 0.06 | 0.06 | 0.06 | 31.86 | 27.79 | 30.62 |
| 7-25-90 | 0.06 | 0.06 | 0.06 | 31.50 | 25.75 | 30.62 |
| 7-26-90 | 0.06 | 0.06 | 0.06 | 29.47 | 25.13 | 28.58 |
| 7-27-90 | 0.06 | 0.06 | 0.06 | 28.32 | 24.51 | 30.53 |
| 7-28-90 | 0.06 | 0.06 | 0.06 | 28.67 | 24.25 | 30.44 |

## TABLE F-14. 76 Hz DAILY AVERAGE CULTURE CELL EM EXPOSURES, 1990
## Soil Amoeba Ground Study Site (page 2 of 2)

| | Current Density (mA/m²) | | | Electric Field (mV/m) | | |
|---|---|---|---|---|---|---|
| Date | Cell 1 | Cell 2 | Cell 3 | Cell 4 | Cell 5 | Cell 6 |
| 7-29-90 | 0.06 | 0.06 | 0.06 | 30.27 | 26.28 | 29.91 |
| 7-30-90 | 0.06 | 0.06 | 0.06 | 31.95 | 27.35 | 32.21 |
| 7-31-90 | 0.06 | 0.06 | 0.06 | 34.87 | 29.82 | 32.39 |
| 8-01-90 | 0.06 | 0.06 | 0.06 | 36.37 | 30.44 | 32.57 |
| 8-02-90 | 0.06 | 0.06 | 0.06 | 35.04 | 30.53 | 32.21 |
| 8-03-90 | 0.06 | 0.06 | 0.06 | 36.11 | 30.53 | 33.01 |
| 8-04-90 | 0.06 | 0.06 | 0.06 | 39.82 | 33.01 | 36.11 |
| 8-05-90 | 0.06 | 0.06 | 0.06 | 45.49 | 34.42 | 38.58 |
| 8-06-90 | 0.06 | 0.06 | 0.06 | 42.92 | 34.34 | 36.99 |
| 8-07-90 | 0.06 | 0.06 | 0.06 | 38.85 | 32.65 | 36.46 |
| 8-08-90 | 0.06 | 0.06 | 0.06 | 35.66 | 30.88 | 35.58 |
| 8-09-90 | 0.06 | 0.06 | 0.06 | 33.45 | 28.58 | 33.19 |
| 8-10-90 | 0.06 | 0.06 | 0.06 | 34.87 | 31.42 | 36.11 |
| 8-11-90 | 0.06 | 0.06 | 0.06 | 39.56 | 32.57 | 36.55 |
| 8-12-90 | 0.06 | 0.06 | 0.06 | 40.80 | 35.49 | 38.94 |
| 8-13-90 | 0.06 | 0.06 | 0.06 | 39.82 | 33.54 | 36.28 |
| 8-14-90 | 0.06 | 0.06 | 0.06 | 38.58 | 31.68 | 35.31 |
| 8-15-90 | 0.06 | 0.06 | 0.06 | 41.50 | 33.19 | 36.28 |
| 8-16-90 | 0.06 | 0.06 | 0.06 | 38.94 | 31.15 | 35.13 |
| 8-17-90 | 0.06 | 0.06 | 0.06 | 38.50 | 29.12 | 34.78 |
| 8-18-90 | 0.06 | 0.06 | 0.06 | 44.96 | 33.19 | 36.81 |
| 8-19-90 | 0.06 | 0.06 | 0.06 | 48.41 | 37.08 | 39.03 |
| 8-20-90 | 0.06 | 0.06 | 0.06 | 46.02 | 35.04 | 37.70 |
| 8-21-90 | 0.06 | 0.06 | 0.06 | 41.50 | 34.25 | 35.75 |
| 8-22-90 | 0.06 | 0.06 | 0.06 | 39.47 | 32.30 | 34.78 |
| 8-23-90 | 0.06 | 0.06 | 0.06 | 38.05 | 31.59 | 35.22 |
| 8-24-90 | 0.06 | 0.06 | 0.06 | 36.99 | 28.76 | 32.92 |
| 8-25-90 | 0.06 | 0.06 | 0.06 | 38.67 | 30.00 | 35.04 |
| 8-26-90 | 0.06 | 0.06 | 0.07 | 42.39 | 32.30 | 34.78 |
| 8-27-90 | 0.06 | 0.06 | 0.06 | 42.48 | 32.39 | 35.49 |
| 8-28-90 | 0.06 | 0.06 | 0.06 | 40.18 | 30.00 | 34.78 |
| 8-29-90 | 0.06 | 0.06 | 0.06 | 36.37 | 29.47 | 35.49 |
| 8-30-90 | 0.06 | 0.06 | 0.06 | 32.57 | 29.29 | 21.68 |
| 8-31-90 | 0.06 | 0.06 | 0.06 | 33.10 | 29.38 | 2.57 |
| 9-01-90 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-02-90 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-03-90 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-04-90 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-05-90 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-06-90 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-07-90 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-08-90 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-09-90 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-10-90 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-11-90 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-12-90 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-13-90 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-14-90 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |
| 9-15-90 | No Cell | No Cell | No Cell | No Cell | No Cell | No Cell |

# APPENDIX G

# BIRD SPECIES AND COMMUNITIES STUDIES

## BIRD SPECIES AND COMMUNITIES STUDIES

The bird species and communities studies census migrating and resident bird populations using a line transect method. Bird populations in a given area are determined both as a whole and by individual species. The magnetic field is considered the most important electromagnetic (EM) factor influencing migrating birds; however, the electric fields in the air and the earth may also have an influence on population distributions.

IITRI field crews made ELF EM field measurements at 24 points within the five treatment and five control transects for the bird species and communities studies in Michigan in 1990. The study transects and the historical measurement points within those transects were unchanged from 1989. The treatment transects in Michigan were further characterized in 1990 by taking additional measurements along these transects at their start and finish, and between each of the eight sub-segments to determine spatial EM field variability. Measurement dates for 1990 and previous years appear in Table G-1.

**TABLE G-1. EM FIELD MEASUREMENT DATES**
**Bird Species and Communities Studies, Michigan**

| Year | Measurement Dates | |
|---|---|---|
| 1984 | Aug 23, 24 | |
| 1985 | May 6, 7 | |
| 1986 | Sep 30 | Oct 3, 6, 7, 13, 16 |
| 1987 | Sep 23-25, 30 | |
| 1988 | Sep 21, 23, 29, 30 | Oct 4-6 |
| 1989 | Sep 11, 14, 15, 18, 20, 22 | |
| 1990 | Sep 25-28 | Oct 3-5, 9, 11, 12 |

The positions of the 10 Michigan transects relative to the NRTF-Republic are shown on the composite map in Figure G-1. The transect numbers listed on the map are those used by IITRI. Table G-2 provides a cross-reference of IITRI transect numbers, investigator transect names, and township, range, and section numbers for the transects.

EM field measurements for Michigan for 1990 and previous years are found in Tables G-3 through G-8. Tables G-3, G-4, and G-5 present 60 Hz data for the air electric field, earth electric field, and magnetic flux density, respectively. Tables G-6, G-7, and G-8 present 76 Hz data for these fields as well as the corresponding operating currents of the NRTF-Republic.

**TABLE G-2. TRANSECT NO. CROSS-REFERENCE**
**Bird Species and Communities Studies**

| IITRI Transect No. | Investigator's Transect Name | Location: Township | : | Range | : | Section(s) |
|---|---|---|---|---|---|---|
| 10C1 | Carney Lake | T41N | : | R29W | : | 33, 34, 35, 36 |
| 10C2 | Skunk Creek | T42N | : | R27W | : | 19, 30 |
| | | T42N | : | R28W | : | 14, 23, 24 |
| 10C5 | Arnold | T43N | : | R25W | : | 31, 32, 33, 34 |
| 10C12 | Lost Lake | T41N | : | R29W | : | 21, 26, 27, 28, 35 |
| 10C13 | Bob's Creek | T44N | : | R26W | : | 13, 23, 24, 26 |
| 10T1 | Leeman's Road | T43N | : | R29W | : | 14, 23, 26, 35 |
| 10T2 | Turner Road | T43N | : | R29W | : | 1, 12 |
| | | T44N | : | R29W | : | 36 |
| 10T3 | Flat Rock Creek | T45N | : | R28W | : | 19, 30, 31 |
| 10T4 | Schwartz Creek | T45N | : | R28W | : | 31 |
| | | T45N | : | R29W | : | 26, 27, 35, 36 |
| 10T11 | Heart Lake | T45N | : | R28W | : | 7, 18, 19 |
| | | T45N | : | R29W | : | 1, 12 |

Considerable year-to-year variability in the 60 Hz EM fields is evident. The primary factors in this variability at treatment sites are changes in power line loading conditions (which are unknown) and differences in the configuration of the antennas at the time of measurement. Notes on the antenna configurations are included in the tables primarily for engineering use. The 60 Hz measurements at treatment transects in 1986, 1987, 1988, and 1990 were taken while the antennas were off, and are representative of 60 Hz levels present during maintenance periods. In 1989, 60 Hz measurements were taken during full-power operation of the antennas with an unmodulated signal. These values indicate that 60 Hz EM fields present during operation of the antennas are comparable to those present when the antennas are off. It was not possible to take 60 Hz measurements at some points on treatment transects in 1989 and 1990 because of antenna operation with a modulated signal. These cases are noted in the data tables.

Annual variations in the 60 Hz EM fields measured at the control transects are also caused by differences in power line loading, but are not dependent on the antennas or their configuration because of the distance of these transects from the antenna. The 60 Hz EM field values at the control transects, nonetheless, are about as variable as those at the treatment transects.

Overall, the 60 Hz EM fields measured at all transects in 1990 are consistent with previous field values and with the expected differences in power line loads and the antenna configuration. Regardless of the field variability associated with the measurement condition, 76 Hz EM fields at the treatment transects

consistently dominate the 60 Hz EM fields at the treatment and control transects, and the ratios of 60 Hz EM fields between matched treatment/control transects continue to meet the exposure criteria guidelines established at the beginning of the study.

The 76 Hz EM field measurements in 1990 were made with 150 ampere antenna currents, the predominant operating current of the NRTF-Republic since 4 May 1989. The antenna currents at which measurements were made in each year are given in the column headings of Tables G-6 through G-8. The annual increases in field magnitudes reflect the level of antenna current at the time of measurement: 4 or 6 amperes in 1986, 15 amperes in 1987, 75 amperes in 1988, and 150 amperes in 1989 and 1990. The 1990 measurements are consistent with the 1989 measurements at the same current, and are proportional to the 1986, 1987, and 1988 measurements made at lower currents.

**EM Field Variations Along Study Transects**

Measured values of the electric and magnetic fields along transects 10T1, 10T2, 10T3, 10T4, and 10T11 are listed in Table G-9. Measurements were taken at the start and finish of each transect and at the "X" flags between transect sub-segments. Table G-9 also includes data from applicable historical measurement locations. Graphs of the EM field intensities along these transects are presented and discussed in Section 4.2.1 of this report.

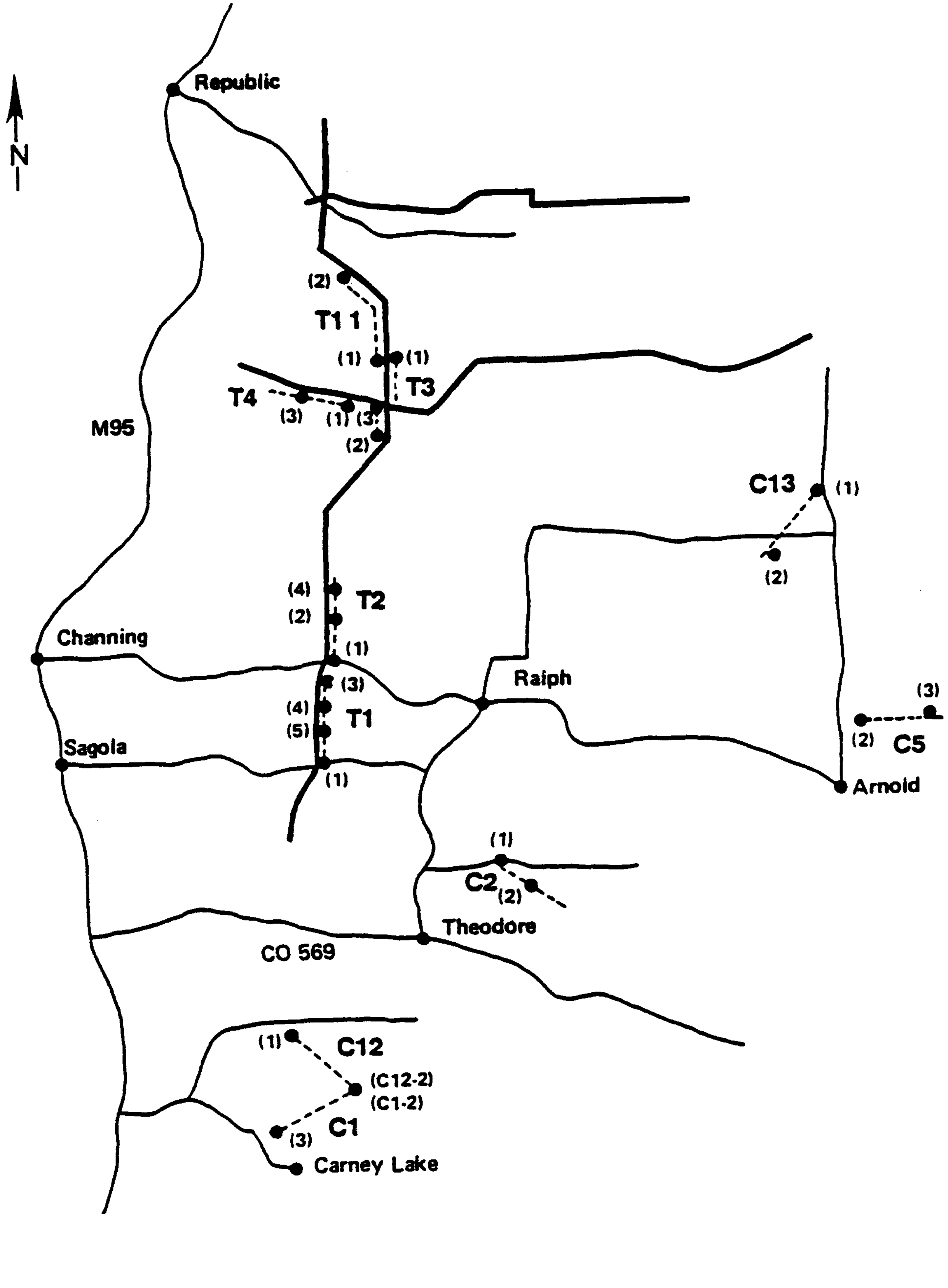



FIGURE G-1. POSITIONS OF BIRD SPECIES AND COMMUNITIES STUDY TRANSECTS RELATIVE TO NRTF-REPUBLIC ANTENNA ELEMENTS.

**TABLE G-3. 60 Hz AIR ELECTRIC FIELD INTENSITIES (V/m)**
**Bird Species and Communities Studies**
**Michigan Transects**

| Site No., Meas. Pt. | 1983[a] | 1984[a] | 1985[a] | 1986[b] | 1987[c] | 1988[c] | 1989[d] | 1990 |
|---|---|---|---|---|---|---|---|---|
| 10C1-2 | - | < | < | < | < | < | < | <[d] |
| 10C1-3 | - | - | < | < | < | < | < | <[d] |
| 10C2-1 | - | < | < | < | < | < | < | <[d] |
| 10C2-2 | - | < | < | < | < | < | < | <[d] |
| 10C5-2 | - | < | < | < | < | < | < | <[d] |
| 10C5-3 | - | < | < | < | < | < | < | <[d] |
| 10C12-1 | - | - | < | < | < | < | < | <[d] |
| 10C12-2 | - | - | < | < | < | < | < | <[d] |
| 10C13-1 | - | - | < | < | < | < | < | <[d] |
| 10C13-2 | - | - | < | < | < | < | < | <[d] |
| 10T1-1 | - | < | < | < | < | < | <0.001 | <[b] |
| 10T1-3 | - | - | < | < | < | < | < | <[b] |
| 10T1-4 | - | - | - | < | < | < | < | <[b] |
| 10T1-5 | - | - | - | < | < | < | <0.001 | <[b] |
| 10T2-1 | - | <0.001 | < | < | < | < | < | <[c] |
| 10T2-2 | - | - | - | < | < | < | < | <[b] |
| 10T2-4 | - | - | < | < | < | 0.008 | # | <[b] |
| 10T3-1 | - | < | < | < | < | < | < | # |
| 10T3-2 | - | < | < | < | < | < | < | # |
| 10T3-3 | - | - | - | < | < | <0.001 | <0.001 | # |
| 10T4-1 | - | < | < | < | < | < | < | # |
| 10T4-3 | - | - | - | < | < | < | < | # |
| 10T11-1 | - | - | < | < | < | <0.001 | <0.001 | # |
| 10T11-2 | - | - | < | < | 0.011 | <0.001 | <0.001 | # |

a = antennas not constructed.
b = antennas off, grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 A current.

\- = measurement point not established.
\# = measurement precluded by antenna operation.
< = measurement est. <0.001 V/m based on earth E-field.

TABLE G-4. 60 Hz EARTH ELECTRIC FIELD INTENSITES (mV/m)
Bird Species and Communities Studies
Michigan Transects

| Site No., Meas. Pt. | 1983[a] | 1984[a] | 1985[a] | 1986[b] | 1987[c] | 1988[c] | 1989[d] | 1990 |
|---|---|---|---|---|---|---|---|---|
| 10C1-2 | - | 0.62 | 0.106,0.141 | 0.101 | 0.059 | 0.20 | 0.073 | 0.27[d] |
| 10C1-3 | - | - | 0.26,0.27 | 0.055 | 0.21 | 0.32 | 0.72 | 0.079[d] |
| 10C2-1 | - | 0.98 | 0.138 | 0.041 | 0.038 | 0.087 | 0.080 | 0.076[d] |
| 10C2-2 | - | 0.35 | 0.21 | 0.055 | 0.048 | 0.047 | 0.069 | 0.076[d] |
| 10C5-2 | - | 0.35 | 0.45 | 0.193 | 0.116 | 0.23 | 0.053 | 0.050[d] |
| 10C5-3 | - | 0.111 | 0.23 | 0.25 | 0.103 | 0.126 | 0.050 | 0.073[d] |
| 10C12-1 | - | - | 0.194,0.28 | 0.058 | 0.256 | 0.98 | 1.19 | 0.22[d] |
| 10C12-2 | - | - | 0.106,0.141 | 0.101 | 0.059 | 0.20 | 0.073 | 0.27[d] |
| 10C13-1 | - | - | 0.34,0.52 | 0.30 | 0.48 | 0.37 | 0.78 | 0.099[d] |
| 10C13-2 | - | - | 0.143,0.31 | 0.139 | 0.157 | 0.121 | 0.039 | 0.074[d] |
| 10T1-1 | - | 0.076 | 0.061 | 0.034 | 0.099 | 0.21 | 0.077 | 0.039[b] |
| 10T1-3 | - | - | 0.38 | 0.120 | 0.20 | 0.51 | # | 0.106[b] |
| 10T1-4 | - | - | - | 0.111 | 0.085 | 0.30 | 0.076 | 0.029[b] |
| 10T1-5 | - | - | - | 0.040 | 0.052 | 0.116 | 0.052 | 0.021[b] |
| 10T2-1 | - | 0.42 | 0.194 | 0.050 | 0.058 | 0.23 | 0.034 | 0.130[c] |
| 10T2-2 | - | - | - | 0.058 | 0.052 | 0.24 | 0.023 | 0.028[b] |
| 10T2-4 | - | - | 0.158 | 0.054 | 0.029 | 0.166 | 0.164 | 0.013[b] |
| 10T3-1 | - | 0.30 | 0.23 | 0.145 | 0.164 | 0.070 | # | # |
| 10T3-2 | - | 0.26 | 0.117 | 0.069 | 0.103 | 0.075 | # | # |
| 10T3-3 | - | - | - | 0.094 | 0.120 | 0.132 | 0.32 | # |
| 10T4-1 | - | 0.29 | 0.132 | 0.129 | 0.093 | 0.087 | # | # |
| 10T4-3 | - | - | - | 0.112 | 0.22 | 0.166 | 0.087 | # |
| 10T11-1 | - | - | 0.23 | 0.172 | 0.106 | 0.095 | 0.25 | # |
| 10T11-2 | - | - | 0.26,0.50 | 0.58 | 0.45 | 0.196 | 0.21 | # |

a = antennas not constructed.
b = antennas grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 A current.
- = measurement point not established.
# = measurement precluded by antenna operation.

TABLE G-5. 60 Hz MAGNETIC FLUX DENSITIES (mG)
Bird Species and Communities Studies
Michigan Transects

| Site No., Meas. Pt. | 1983[a] | 1984[a] | 1985[a] | 1986[b] | 1987[c] | 1988[c] | 1989[d] | 1990 |
|---|---|---|---|---|---|---|---|---|
| 10C1-2 | - | 0.001 | 0.001 | <0.001 | <0.001 | 0.001 | 0.001 | 0.001[d] |
| 10C1-3 | - | - | 0.001,0.003 | <0.001 | 0.003 | 0.002 | 0.007 | 0.002[d] |
| 10C2-1 | - | 0.005 | 0.004 | <0.001 | <0.001 | <0.001 | 0.001 | 0.001[d] |
| 10C2-2 | - | 0.003 | 0.003 | <0.001 | 0.001 | 0.001 | 0.001 | 0.001[d] |
| 10C5-2 | - | 0.008 | 0.009 | 0.006 | 0.005 | 0.006 | 0.002 | 0.001[d] |
| 10C5-3 | - | 0.001 | 0.002 | 0.002 | 0.001 | 0.001 | 0.001 | 0.001[d] |
| 10C12-1 | - | - | 0.001,0.003 | 0.002 | 0.003 | 0.011 | 0.009 | 0.001[d] |
| 10C12-2 | - | - | 0.001 | <0.001 | <0.001 | 0.001 | 0.001 | 0.001[d] |
| 10C13-1 | - | - | 0.007,0.010 | 0.007 | 0.005 | 0.003 | 0.009 | 0.003[d] |
| 10C13-2 | - | - | 0.001,<0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001[d] |
| 10T1-1 | - | 0.006 | 0.004 | 0.002 | 0.005 | 0.016 | 0.005 | 0.002[b] |
| 10T1-3 | - | - | 0.002 | 0.003 | 0.005 | 0.017 | # | 0.003[b] |
| 10T1-4 | - | - | - | 0.003 | 0.003 | 0.009 | 0.002 | 0.001[b] |
| 10T1-5 | - | - | - | 0.003 | 0.016 | 0.012 | 0.003 | 0.001[b] |
| 10T2-1 | - | 0.002 | 0.002 | 0.003 | 0.005 | 0.012 | 0.001 | 0.007[c] |
| 10T2-2 | - | - | - | <0.001 | 0.002 | 0.008 | 0.001 | 0.001[b] |
| 10T2-4 | - | - | 0.001 | 0.002 | 0.001 | 0.004 | 0.001 | <0.001[b] |
| 10T3-1 | - | 0.001 | 0.001 | 0.006 | 0.003 | 0.004 | # | # |
| 10T3-2 | - | 0.001 | <0.001 | 0.008 | 0.005 | 0.004 | # | # |
| 10T3-3 | - | - | - | 0.012 | 0.007 | G.017 | 0.010 | # |
| 10T4-1 | - | 0.001 | <0.001 | 0.002 | 0.002 | 0.003 | # | # |
| 10T4-3 | - | - | - | 0.001 | 0.003 | 0.004 | 0.002 | # |
| 10T11-1 | - | - | <0.001 | 0.006 | 0,006 | 0.003 | 0.003 | # |
| 10T11-2 | - | - | 0.001,<0.001 | 0.008 | 0.005 | 0.004 | <0.001 | # |

a = antennas not constructed.
b = antennas grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 A current.

\- = measurement point not established.
# = measurement precluded by antenna operation.

TABLE G-6. 76 Hz AIR ELECTRIC FIELD INTENSITIES (V/m)
Bird Species and Communities Studies
Michigan Transects

| Site No., Meas. Pt. | 1986 NS 4 amps | 1986 NEW 6 amps | 1986 SEW 6 amps | 1986 SEW 10 amps (EX) | 1987 NS 15 amps | 1987 EW 15 amps | 1988 NS 75 amps | 1988 EW 75 amps | 1989 B 150 amps | 1990 B 150 amps |
|---|---|---|---|---|---|---|---|---|---|---|
| 10C1-2 | < | < | < | * | < | < | < | < | < | < |
| 10C1-3 | < | < | < | * | < | < | < | < | < | < |
| 10C2-1 | < | < | < | * | < | < | < | < | < | < |
| 10C2-2 | < | < | < | * | < | < | < | < | < | < |
| 10C5-2 | < | < | < | * | < | < | < | < | < | < |
| 10C5-3 | < | < | < | * | < | < | < | < | < | < |
| 10C12-1 | < | < | < | * | < | < | < | < | < | < |
| 10C12-2 | < | < | < | * | < | < | < | < | < | < |
| 10C13-1 | < | < | < | * | < | < | < | < | < | < |
| 10C13-2 | < | < | < | * | < | < | < | < | < | < |
| 10T1-1 | < | < | < | * | 0.005 | < | 0.022 | < | 0.036 | 0.036 |
| 10T1-3 | 0.002 | < | < | * | 0.007 | < | 0.038 | <0.001 | 0.068 | 0.081 |
| 10T1-4 | < | < | < | * | 0.004 | < | 0.024 | < | 0.036 | 0.040 |
| 10T1-5 | < | < | < | * | 0.003 | < | 0.010 | < | 0.022 | 0.020 |
| 10T2-1 | 0.002 | < | < | * | 0.006 | < | 0.033 | <0.001 | 0.059 | 0.088 |
| 10T2-2 | 0.002 | < | < | * | 0.007 | < | 0.047 | 0.003 | 0.062 | 0.062 |
| 10T2-4 | 0.002 | < | < | * | 0.007 | < | 0.028 | 0.007 | 0.062 | 0.060 |
| 10T3-1 | 0.004 | < | < | * | 0.005 | 0.003 | 0.016 | 0.019 | 0.040 | 0.050 |
| 10T3-2 | 0.004 | < | 0.001 | 0.002 | 0.006 | 0.003 | 0.048 | 0.034 | 0.071 | 0.070 |
| 10T3-3 | 0.005 | < | 0.017 | 0.028 | 0.005 | 0.009 | 0.046 | 0.120 | 0.170 | 0.130 |
| 10T4-1 | 0.002 | < | 0.003 | 0.005 | 0.003 | 0.006 | 0.042 | 0.038 | 0.049 | 0.051 |
| 10T4-3 | < | < | 0.003 | 0.005 | 0.001 | 0.008 | 0.018 | 0.054 | 0.078 | 0.062 |
| 10T11-1 | < | < | < | * | 0.004 | 0.002 | 0.019 | 0.014 | 0.051 | 0.053 |
| 10T11-2 | < | < | < | * | 0.038 | 0.009 | 0.059 | 0.017 | 0.108 | 0.27 |

NS = north-south antenna.
EW = east-west antenna.
NEW = northern EW antenna element.
SEW = southern EW antenna element.
B = NS + EW antennas, standard phasing.

EX = extrapolated data.
* = data cannot be extrapolated.
< = measurement est. <0.001 V/m based on earth E-field.

TABLE G-7. 76 Hz EARTH ELECTRIC FIELD INTENSITIES (mV/m)
Bird Species and Communities Studies
Michigan Transects

| Site No., Meas. Pt. | 1986 NS 4 amps | 1986 NEW 6 amps | 1986 SEW 6 amps | 1986 SEW 10 amps (EX) | 1987 NS 15 amps | 1987 EW 15 amps | 1988 NS 75 amps | 1988 EW 75 amps | 1989 B 150 amps | 1990 B 150 amps |
|---|---|---|---|---|---|---|---|---|---|---|
| 10C1-2 | 0.004 | 0.003 | 0.004 | 0.007 | 0.015 | 0.012 | 0.074 | 0.058 | 0.153 | 0.31 |
| 10C1-3 | 0.013 | 0.004 | 0.002 | 0.003 | 0.049 | 0.011 | 0.26 | 0.060 | 0.41 | 0.44 |
| 10C2-1 | 0.017 | 0.002 | 0.007 | 0.012 | 0.073 | 0.021 | 0.30 | 0.095 | 0.78 | 0.70 |
| 10C2-2 | 0.011 | 0.003 | 0.007 | 0.012 | 0.037 | 0.020 | 0.176 | 0.100 | 0.33 | 0.43 |
| 10C5-2 | 0.001 | 0.003 | 0.007 | 0.012 | 0.014 | 0.023 | 0.073 | 0.119 | 0.26 | 0.28 |
| 10C5-3 | 0.005 | 0.003 | 0.009 | 0.015 | 0.017 | 0.027 | 0.091 | 0.143 | 0.30 | 0.28 |
| 10C12-1 | 0.028 | 0.010 | 0.011 | 0.018 | 0.068 | 0.028 | 0.36 | 0.140 | 1.37 | 0.76 |
| 10C12-2 | 0.004 | 0.003 | 0.004 | 0.007 | 0.015 | 0.012 | 0.074 | 0.058 | 0.153 | 0.31 |
| 10C13-1 | 0.024 | 0.027 | 0.104 | 0.173 | 0.057 | 0.24 | 0.32 | 1.39 | 4.8 | 4.2 |
| 10C13-2 | 0.024 | 0.023 | 0.098 | 0.163 | 0.089 | 0.29 | 0.34 | 1.07 | 2.1 | 2.7 |
| 10T1-1 | 0.85 | 0.028 | 0.008 | 0.013 | 2.8 | 0.015 | 13.0 | 0.115 | 42 | 32 |
| 10T1-3 | 2.2 | 0.068 | 0.077 | 0.128 | 7.1 | 0.147 | 33 | 0.86 | 74 | 82 |
| 10T1-4 | 0.96 | 0.030 | 0.031 | 0.052 | 4.1 | 0.087 | 19.8 | 0.46 | 35 | 42 |
| 10T1-5 | 0.65 | 0.020 | 0.006 | 0.010 | 2.3 | 0.015 | 10.9 | 0.098 | 20 | 19.7 |
| 10T2-1 | 1.42 | 0.043 | 0.077 | 0.128 | 5.3 | 0.25 | 31 | 1.05 | 48 | 44 |
| 10T2-2 | 1.69 | 0.056 | 0.107 | 0.178 | 7.0 | 0.34 | 33 | 1.77 | 53 | 65 |
| 10T2-4 | 0.59 | 0.056 | 0.158 | 0.26 | 5.0 | 0.49 | 26 | 2.6 | 79 | 71 |
| 10T3-1 | 0.82 | 0.23 | 0.60 | 1.00 | 4.9 | 2.1 | 26 | 10.1 | 47 | 46 |
| 10T3-2 | 1.24 | 0.133 | 1.05 | 1.75 | 5.4 | 2.7 | 21 | 31 | 61 | 66 |
| 10T3-3 | 1.36 | (0.35) | 3.6 | 6.0 | 4.8 | 7.5 | 43 | 54 | 111 | 105 |
| 10T4-1 | 0.88 | 0.137 | 1.58 | 2.6 | 2.4 | 4.8 | 14.5 | 19.3 | 62 | 61 |
| 10T4-3 | 0.46 | 0.139 | 1.92 | 3.2 | 1.30 | 8.1 | 5.4 | 39 | 68 | 66 |
| 10T11-1 | 0.67 | 0.27 | 0.59 | 0.98 | 3.9 | 1.97 | 17.6 | 8.9 | 47 | 49 |
| 10T11-2 | 1.38 | 0.93 | 0.44 | 0.73 | 7.3 | 2.9 | 32 | 12.6 | 105 | 86 |

NS = north-south antenna.
EW = east-west antenna.
NEW = northern EW antenna element.
SEW = southern EW antenna element.
B = NS + EW antennas, standard phasing.

EX = extrapolated data.
() = estimated data.

**TABLE G-8. 76 Hz MAGNETIC FLUX DENSITIES (mG)**
**Bird Species and Communities Studies**
**Michigan Transects**

| Site No., Meas. Pt. | 1986 NS 4 amps | 1986 NEW 6 amps | 1986 SEW 6 amps | 1986 SEW 10 amps (EX) | 1987 NS 15 amps | 1987 EW 15 amps | 1988 NS 75 amps | 1988 EW 75 amps | 1989 B 150 amps | 1990 B 150 amps |
|---|---|---|---|---|---|---|---|---|---|---|
| 10C1-2 | <0.001 | <0.001 | <0.001 | * | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | 0.001 |
| 10C1-3 | <0.001 | <0.001 | <0.001 | * | <0.001 | <0.001 | 0.002 | <0.001 | 0.003 | 0.003 |
| 10C2-1 | <0.001 | <0.001 | <0.001 | * | 0.001 | 0.001 | 0.005 | 0.002 | 0.009 | 0.009 |
| 10C2-2 | <0.001 | <0.001 | <0.001 | * | 0.001 | <0.001 | 0.003 | 0.002 | 0.005 | 0.005 |
| 10C5-2 | <0.001 | <0.001 | <0.001 | * | <0.001 | 0.001 | 0.001 | 0.002 | 0.005 | 0.005 |
| 10C5-3 | <0.001 | <0.001 | <0.001 | * | <0.001 | <0.001 | 0.001 | 0.001 | 0.003 | 0.003 |
| 10C12-1 | <0.001 | <0.001 | <0.001 | * | <0.001 | <0.001 | 0.002 | 0.001 | 0.004 | 0.004 |
| 10C12-2 | <0.001 | <0.001 | <0.001 | * | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | 0.001 |
| 10C13-1 | <0.001 | <0.001 | <0.001 | * | 0.001 | 0.002 | 0.002 | 0.009 | 0.066 | 0.066 |
| 10C13-2 | <0.001 | <0.001 | <0.001 | * | <0.001 | 0.001 | 0.002 | 0.006 | 0.015 | 0.015 |
| 10T1-1 | 0.044 | 0.001 | <0.001 | * | 0.179 | 0.001 | 0.84 | 0.005 | 1.87 | 1.63 |
| 10T1-3 | 0.047 | 0.001 | 0.007 | 0.012 | 0.176 | 0.001 | 0.84 | 0.010 | 1.70 | 1.62 |
| 10T1-4 | 0.026 | 0.001 | 0.001 | 0.002 | 0.103 | 0.002 | 0.49 | 0.014 | 1.02 | 0.95 |
| 10T1-5 | 0.034 | 0.001 | 0.001 | 0.002 | 0.49 | 0.002 | 0.61 | 0.008 | 1.31 | 1.20 |
| 10T2-1 | 0.066 | 0.002 | 0.001 | 0.002 | 0.25 | 0.001 | 1.21 | 0.010 | 2.5 | 2.4 |
| 10T2-2 | 0.043 | 0.001 | 0.001 | 0.002 | 0.165 | 0.002 | 0.80 | 0.010 | 1.61 | 1.54 |
| 10T2-4 | 0.026 | 0.001 | 0.001 | 0.002 | 0.097 | 0.002 | 0.46 | 0.005 | 0.97 | 0.92 |
| 10T3-1 | 0.029 | 0.003 | 0.007 | 0.012 | 0.188 | 0.015 | 0.96 | 0.078 | 1.89 | 1.87 |
| 10T3-2 | 0.081 | 0.002 | 0.013 | 0.022 | 0.29 | 0.031 | 1.61 | 0.161 | 2.9 | 2.9 |
| 10T3-3 | 0.116 | (0.040) | 0.58 | 0.97 | 0.196 | 0.89 | 1.11 | 7.7 | 15.0 | 14.3 |
| 10T4-1 | 0.025 | 0.001 | 0.081 | 0.135 | 0.038 | 0.191 | 0.20 | 1.00 | 1.92 | 1.89 |
| 10T4-3 | 0.025 | 0.001 | 0.119 | 0.198 | 0.011 | 0.32 | 0.051 | 1.42 | 2.9 | 2.7 |
| 10T11-1 | 0.033 | 0.002 | 0.006 | 0.010 | 0.24 | 0.015 | 1.09 | 0.072 | 2.3 | 2.3 |
| 10T11-2 | 0.042 | 0.003 | 0.003 | 0.005 | 0.31 | 0.006 | 1.42 | 0.033 | 2.9 | 2.8 |

NS = north-south antenna.
EW = east-west antenna.
NEW = northern EW antenna element.
SEW = southern EW antenna element.
B = NS + EW antennas, standard phasing.

EX = extrapolated data.
() = estimated data.
* = data cannot be extrapolated.

TABLE G-9. 1990 EM FIELD VARIATIONS ALONG MICHIGAN TRANSECTS
BIRD SPECIES AND COMMUNITIES STUDIES

| Study Transect | Sub-transect Location | Magnetic Flux Density (mG) | Earth Electric Field Intensity (mV/m) |
|---|---|---|---|
| 10T1-1 | Start A | 1.63 | 32 |
| 10T1 | AXB | 1.64 | 38 |
| 10T1 | BXC | 1.48 | 42 |
| 10T1 | CXD | 1.02 | 14.8 |
| 10T1-5 | D2 | 1.20 | 19.7 |
| 10T1 | DXE | 1.26 | 22 |
| 10T1 | EXF | 0.93 | 28 |
| 10T1-4 | F2 | 0.95 | 42 |
| 10T1 | FXG | 1.01 | 21 |
| 10T1 | GXH | 1.34 | 71 |
| 10T1-3 | H9 | 1.62 | 82 |
| 10T1 | End H | 1.30 | 90 |
| 10T2-1 | Start A | 2.4 | 44 |
| 10T2 | AXB | 0.89 | 31 |
| 10T2 | BXC | 0.92 | 18 |
| 10T2 | CXD | 1.01 | 90 |
| 10T2 | DXE | 1.42 | 47 |
| 10T2-2 | E3 | 1.54 | 65 |
| 10T2 | EXF | 1.43 | 52 |
| 10T2 | FXG | 1.30 | 41 |
| 10T2 | GXH | 1.06 | 48 |
| 10T2-4 | H5 | 0.92 | 71 |
| 10T2 | End H | 0.75 | 78 |
| 10T3-1 | Start A | 1.87 | 46 |
| 10T3 | AXB | 2.6 | 94 |
| 10T3 | BXC | 2.5 | 69 |
| 10T3 | CXD | 1.80 | 74 |
| 10T3 | DXE | 1.30 | 75 |
| 10T3 | EXF | 1.40 | 93 |
| 10T3-3 | Start G | 14.3 | 105 |
| 10T3 | GXH | 3.2 | 54 |
| 10T3-2 | End H | 2.9 | 66 |
| 10T4-1 | Start A | 1.89 | 61 |
| 10T4 | AXB | 3.3 | 73 |
| 10T4 | BXC | 3.9 | 81 |
| 10T4 | CXD | 5.2 | 61 |
| 10T4 | DXE | 2.5 | 62 |
| 10T4 | EXF | 3.4 | 46 |
| 10T4-3 | F3 | 2.7 | 66 |
| 10T4 | FXG | 1.90 | 57 |
| 10T4 | GXH | 2.0 | 53 |
| 10T4 | End H | 1.13 | 37 |
| 10T11-1 | Start A | 2.3 | 49 |
| 10T11 | AXB | 1.70 | 53 |
| 10T11 | End B | 1.50 | 55 |
| 10T11 | CXD | 1.46 | 39 |
| 10T11 | DXE | 1.40 | 44 |
| 10T11 | EXF | 1.50 | 55 |
| 10T11 | FXG | 2.3 | 67 |
| 10T11 | GXH | 1.74 | 69 |
| 10T11 | End H | 1.40 | 52 |

Notes: Measurements taken at "X" flag between sub-transects except as noted.
Antenna conditions: 150 amperes, 76 Hz.

# APPENDIX H

## ELECTROMAGNETIC EXPOSURE CRITERIA

## ELECTROMAGNETIC EXPOSURE CRITERIA

Because the electromagnetic (EM) field intensities and/or exposure durations required to produce a bioeffect are not known, EM exposure criteria were established to assist investigators in selecting study sites. These exposure criteria ensure that the 76 Hz EM fields at a treatment site are significantly larger than the 76 Hz EM fields at its paired control site, and also significantly larger than the 60 Hz EM fields at both sites. In addition, the exposure criteria verify that there is not a substantial difference in the ambient 60 Hz EM field intensities between the treatment and control sites.

The EM exposure criteria used in site selection are expressed in equation form as follows:

$$T_{(76\ Hz)}/C_{(76\ Hz)} > 10 \tag{1}$$

$$T_{(76\ Hz)}/T_{(60\ Hz)} > 10 \tag{2}$$

$$T_{(76\ Hz)}/C_{(60\ Hz)} > 10 \tag{3}$$

$$0.1 < T_{(60\ Hz)}/C_{(60\ Hz)} < 10 \tag{4}$$

where $T_{(76\ Hz)}$ = treatment site exposure due to ELF Communications System
$T_{(60\ Hz)}$ = treatment site exposure due to power lines
$C_{(76\ Hz)}$ = control site exposure due to ELF Communications System
$C_{(60\ Hz)}$ = control site exposure due to power lines

Based on the exposure assessment, each possible treatment and control site pairing was classified as acceptable, conditionally acceptable, or unacceptable. These categories are defined as follows:

**Acceptable**. A treatment/control site pair was placed in this category if it satisfied all four EM exposure inequalities for each of the EM fields applicable to the study. For example, the small mammals and nesting birds studies would be concerned with both the soil and air electric fields as well as the magnetic fields. The soil arthropods and earthworms studies, however, would not be concerned with the electric field in the air, since this field terminates at the earth's surface and would not be expected to impact biota existing in the soil or litter layer.

**Conditionally Acceptable**. A treatment/control site pair was placed in this category if it approached, but did not meet, the criteria for acceptability. This category was established because the EM exposure criteria were not rigidly defined. The assumption was made that a difference of one order of magnitude or more would constitute a significant difference

between treatment and control sites for these studies, but without knowing what effects will be experienced, if any. It is difficult to define this difference *a priori*. Furthermore, the EM field measurements themselves encompass a certain degree of error, as do any physical measurements.

**Unacceptable**. A treatment/control site pair was placed in this category if it neither satisfied the criteria for acceptability nor qualified for conditional acceptability.

# APPENDIX I

## ELECTROMAGNETIC EXPOSURE SETUP PROTOCOLS FOR SOIL AMOEBA STUDIES

## ELECTROMAGNETIC EXPOSURE SETUP PROTOCOLS FOR SOIL AMOEBA STUDIES

This appendix documents the protocol written by IITRI to assist the soil amoeba study investigator in setting up his study sites using the culture cell exposure hardware fabricated by IITRI. The protocol also provides guidelines for adjusting the control boxes for proper EM exposures in the cells and for measuring the control voltages necessary to determine the cell exposure parameters.

### MATCHED ELECTRIC FIELD PROTOCOL

(1) Measure maximum electric field, E, in soil, using 1-meter probe.

(2) Multiply electric field value by 0.15 to determine the minimum required drive voltage, $V_{DR}$ (min).

$$V_{DR}\text{ (min)} = E \times 0.15 \text{ (volts)}$$

(3) Locate collector electrodes in line with the maximum electric field in the earth, and spaced far enough apart to generate a voltage across a 2000-ohm resistor that is greater than or equal to $V_{DR}$ (min) (see Figure I-1).

(4) Measure and record electrode spacing and the open circuit (no load) electrode voltage, $V_{OC}$.

(5) Connect the test cell and control box to the electrodes (see Figure I-2). While monitoring the test cell voltage, $V_{CL}$, adjust the variable resistor so that $V_{CL}$ is equal to the value given by the following formula:

$$V_{CL} = E \times 0.113 \text{ (volts)}$$

(6) With the cell voltage set, measure and record the voltage across the 100-ohm series resistor, $V_R$. This allows calculation of the cell current and current density.

(7) Measure and record the electrode voltage, $V_{DR}$, with the test cell and monitoring box connected and adjusted as per Step 5, above.

### MATCHED CURRENT DENSITY PROTOCOL

(1) Measure maximum electric field, E, in soil, using 1-meter probe.

(2) Locate collector electrodes in line with maximum electric field, with a separation of 1 meter.

(3) Measure exact electrode spacing and open circuit (no load) electrode voltage, $V_{OC}$. Measured voltage should be within a few percent of that measured in Step 1. If not, correct electrode spacing as appropriate.

(4) Connect current-limiting control box (see Figure I-3) to electrodes. Place the current limit select switch to the 2.5-megohm position (2.5 M).

(5) Measure and record the voltages across the test cell, $V_{CL}$, the resistor, $V_R$, and the electrodes, $V_{DR}$, using the test point jacks (see Figure I-3 for test point numbering).

The voltages across the resistor and across the electrodes should be close in value to $V_{OC}$ from Step 3.

$$V_R \approx V_{DR} \approx V_{OC}$$

The voltage across the test cell will be much lower, and can be estimated as:

$$V_{CL} \approx 0.6 \times 10^{-3} \times V_{OC} \text{ (volts).}$$

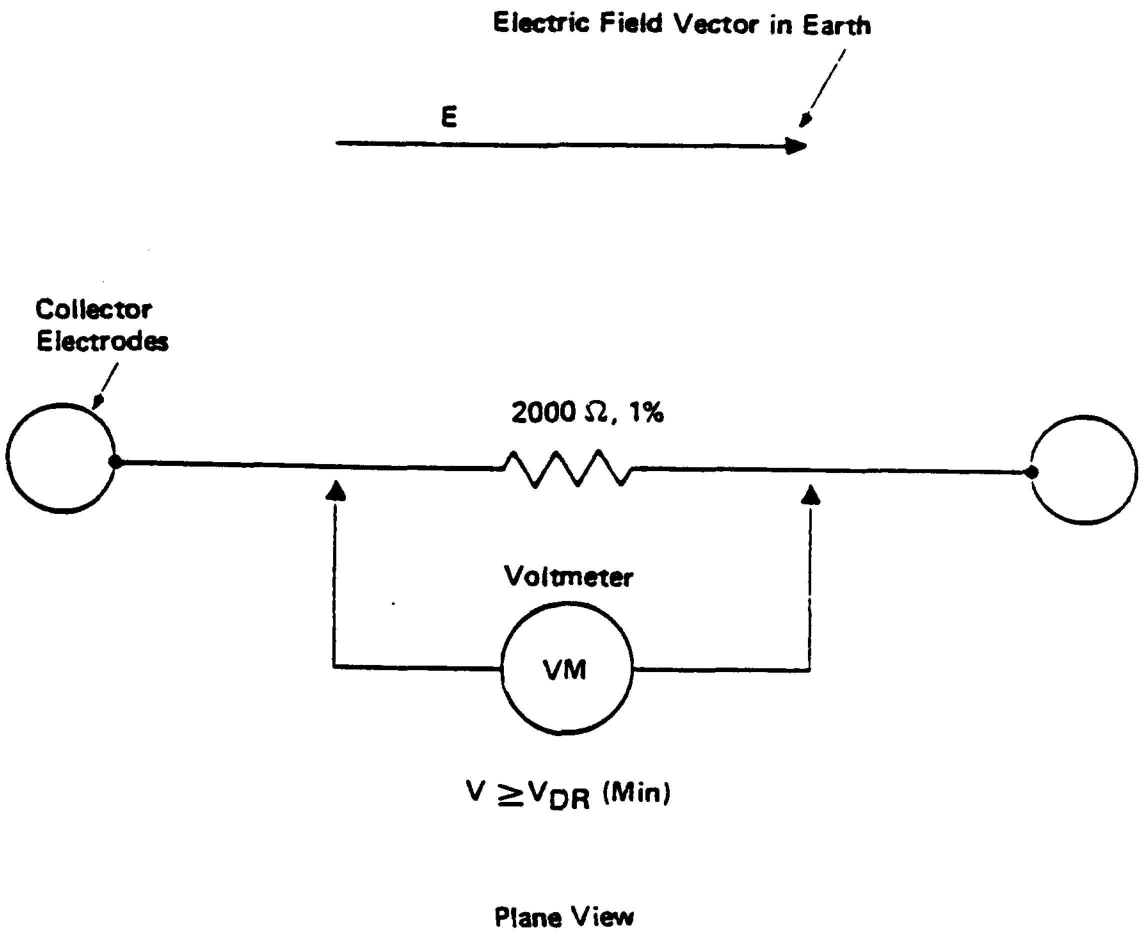
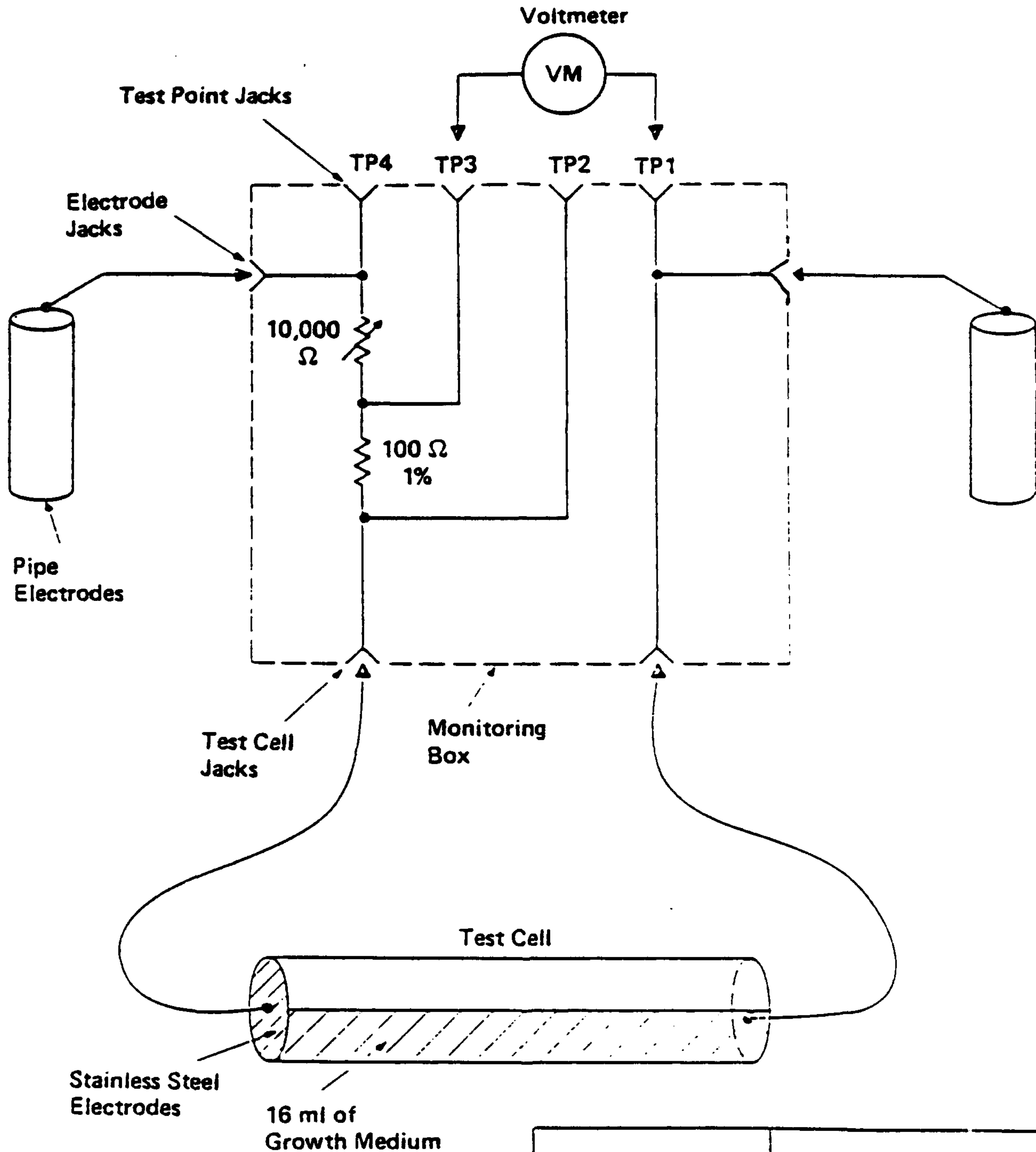
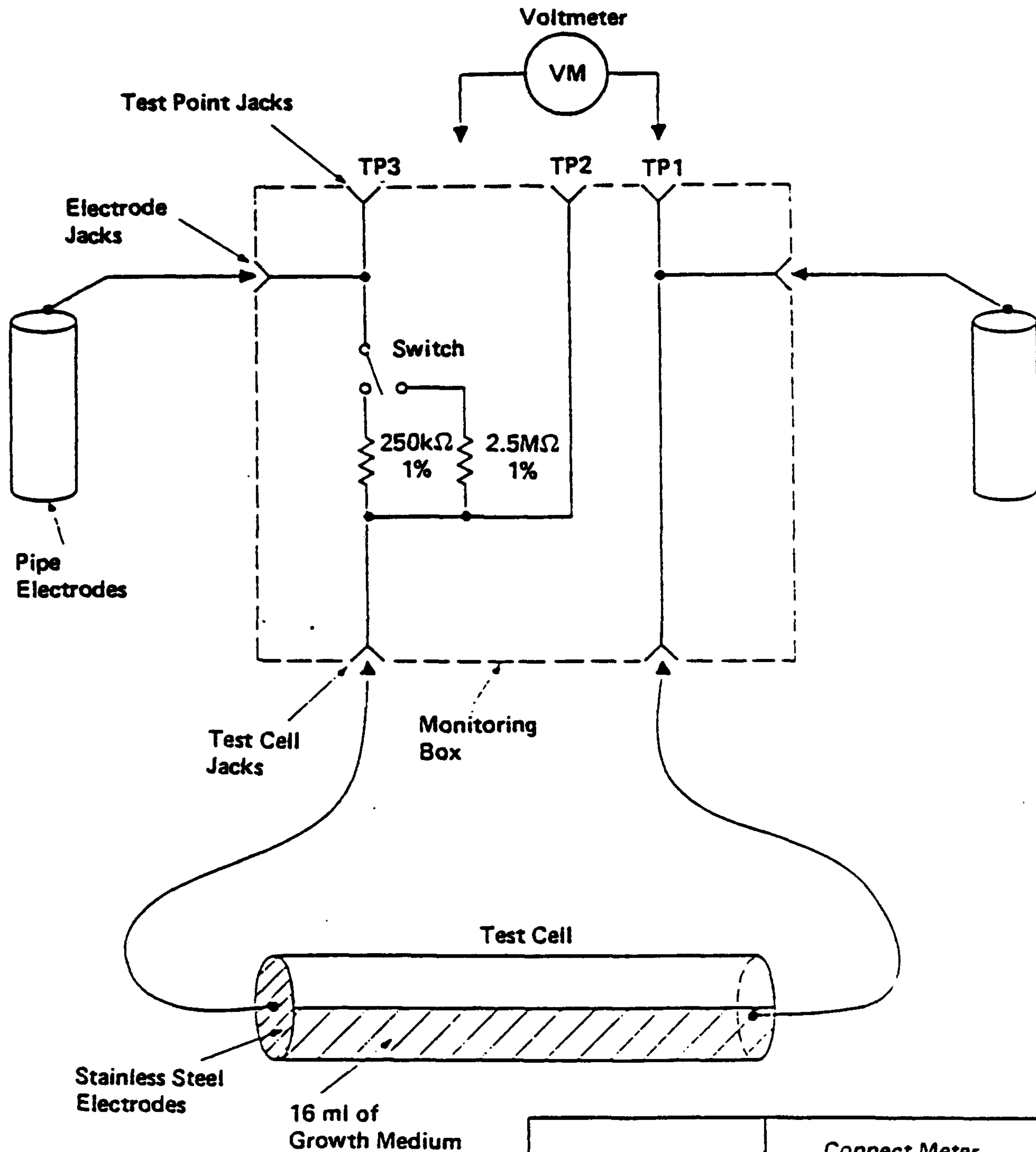



**FIGURE I-1. DETERMINATION OF DRIVE VOLTAGE FOR THE SOIL AMOEBA STUDIES MATCHED ELECTRIC FIELD PROTOCOL.**




| To Measure | Connect Meter Across |
|---|---|
| $V_{CL}$ | TP1 – TP2 |
| $V_R$ | TP2 – TP3 |
| $V_{DR}$ | TP1 – TP4 |

**FIGURE I-2. CONTROL BOX CONNECTIONS FOR MATCHED ELECTRIC FIELD CELLS.**




| To Measure | Connect Meter Across |
|---|---|
| $V_{CL}$ | TP1 – TP2 |
| $V_R$ | TP2 – TP3 |
| $V_{DR}$ | TP1 – TP3 |

**FIGURE I-3. CONTROL BOX CONNECTIONS FOR MATCHED CURRENT DENSITY CELLS.**

# APPENDIX J

## SUMMARY OF OPERATION, NRTF-REPUBLIC

## SUMMARY OF OPERATION, NRTF-REPUBLIC

The operations of the NRTF-Republic during 1986-1990 have been summarized in response to requests from investigators for information on operating schedules. The summary is partitioned according to antenna configuration, modulation, frequency, and antenna current. Separate tables exist for each antenna configuration for each year. Tables J-1, J-2, and J-3 show the number of hours of operation per month in 1986 for the NS, NEW, and SEW antenna or antenna element. Tables J-4 through J-7 show the number of hours of operation per month in 1987 and 1988 for the NS and EW antennas. Tables J-8 through J-13 show the number of hours of operation per month in 1989 and 1990 for the NS, EW, and both (B) antennas. These tables provide monthly and annual breakdowns of the operation of the NRTF-Republic by antenna current, frequency, and signal type. Subtotals within each column denote the hours of modulated and unmodulated signal operation. The bottom row of the tables gives an estimate of the number of on/off cycles of the antenna or element on a monthly and annual basis. An on/off cycle is defined as one power up and one power down of an antenna or element.

Throughout 1986, 1987, 1988, and early 1989, the NRTF-Republic operated primarily to conduct system testing and to take measurements of coupled interference on public utilities. In this operating mode, the antenna elements were cycled on and off as needed to facilitate measurements. In 1986, the cycling of the antennas was dictated primarily by measurement crews via radio communication with the transmitting site. As testing efforts grew in 1987, 1988, and early 1989, the antennas were automatically cycled on and off during testing hours on a 15-minute rotational cycle. The cycle was divided into three 5-minute periods of NS antenna operation, EW antenna operation, and no antenna operation, as described in Section 4.3.6.2 of this report. This procedure permitted several measurement crews to perform measurements simultaneously.

The NRTF-Republic operating logs routinely provided to IITRI for this period typically showed only the daily beginning and ending times of the 15-minute rotational cycle operation periods. Separate entries were not included for each change of antenna elements during the cycling, nor were deviations from the cycle necessarily accounted for. Thus, the exact number of on/off cycles and duration of operating time for each antenna element could not be determined exactly, but were estimated by the procedure described below for 1987, 1988, and early 1989.

The total number of on/off cycles for each element was calculated by multiplying the number of hours between the start and finish of the rotational cycling of the antenna elements by 4, since each element had one on/off cycle every 15 minutes. The monthly operation time for each antenna during rotational cycling of the NRTF-Republic was calculated by multiplying the total time period of the rotational cycling

by one-third. This is because each element was estimated to have a 33% duty cycle during cyclic operation periods.

Calculation of operating times and the number of on/off cycles during periods when rotational cycling was not employed (1986, late 1989, and 1990) were made by directly summming operating time periods and antenna power-up events from the NRTF-Republic operating logs. The estimates of NRTF-Republic operating time and on/off cycles calculated by the above procedures were judged adequate for general use. However, IITRI can obtain exact, minute-by-minute log data for the NRTF-Republic for specific periods as required by the researchers.

TABLE J-1. 1986 OPERATIONS SUMMARY, NRTF-REPUBLIC: NORTH-SOUTH ANTENNA ONLY
(Hours of Operation)

| Frequency, Hz | Month | | | | | | | | | | | | Annual Totals |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | |
| **Mode: Modulated Signal[a]** | | | | | | | | | | | | | |
| 76 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Subtotals | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Mode: Unmodulated Signal** | | | | | | | | | | | | | |
| 76 (4 Amps) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 24.43 | 16.74 | 10.71 | 11.49 | 0.00 | 0.00 | 63.37 |
| 76 (6 Amps) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 | 0.00 | 0.00 | 0.00 | 0.11 |
| 76 (10 Amps) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Subtotals | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 24.43 | 16.74 | 10.82 | 11.49 | 0.00 | 0.00 | 63.48 |
| Other[b] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.07 | 0.00 | 0.00 | 0.00 | 0.07 |
| Totals | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 24.43 | 16.74 | 10.89 | 11.49 | 0.00 | 0.00 | 63.55 |
| Antenna On/Off Cycles | 0 | 0 | 0 | 0 | 0 | 0 | 145 | 23 | 31 | 60 | 0 | 0 | 259 |

[a]Frequencies listed refer to the center frequency of modulation.

[b]Denotes short periods of time at other frequencies or undesignated operation.

TABLE J-2. 1986 OPERATIONS SUMMARY, NRTF-REPUBLIC: NORTHERN EAST-WEST ANTENNA ELEMENT ONLY
(Hours of Operation)

| Frequency, Hz | Month | | | | | | | | | | | | Annual Totals |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | |
| | | | | | | Mode: Modulated Signal[a] | | | | | | | |
| 76 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Subtotals | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | | | | | Mode: Unmodulated Signal | | | | | | | |
| 76 (4 Amps) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.11 | 0.00 | 0.00 | 0.00 | 0.16 |
| 76 (6 Amps) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 18.87 | 13.80 | 0.36 | 2.46 | 9.15 | 0.00 | 0.00 | 44.64 |
| 76 (10 Amps) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Subtotals | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 18.87 | 13.80 | 0.41 | 2.57 | 9.15 | 0.00 | 0.00 | 44.80 |
| Other[b] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 | 0.00 | 0.00 | 0.00 | 0.06 |
| Totals | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 18.87 | 13.80 | 0.41 | 2.63 | 9.15 | 0.00 | 0.00 | 44.86 |
| Antenna On/Off Cycles | 0 | 0 | 0 | 0 | 0 | 55 | 10 | 2 | 26 | 83 | 0 | 0 | 176 |

[a]Frequencies listed refer to the center frequency of modulation.

[b]Denotes short periods of time at other frequencies or undesignated operation.

TABLE J-3. 1986 OPERATIONS SUMMARY, NRTF-REPUBLIC: SOUTHERN EAST-WEST ANTENNA ELEMENT ONLY
(Hours of Operation)

| Frequency, Hz | Month | | | | | | | | | | | | Annual Totals |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | |
| | | | | | | Mode: Modulated Signal[a] | | | | | | | |
| 76 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Subtotals | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | | | | | Mode: Unmodulated Signal | | | | | | | |
| 76 (4 Amps) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.01 | 0.00 | 0.00 | 0.00 | 0.05 |
| 76 (6 Amps) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 11.72 | 0.00 | 0.00 | 5.26 | 5.76 | 0.00 | 0.00 | 22.74 |
| 76 (10 Amps) | 0.00 | 0.00 | 3.87 | 18.64 | 6.15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 28.66 |
| Subtotals | 0.00 | 0.00 | 3.87 | 18.64 | 6.15 | 11.72 | 0.00 | 0.04 | 5.27 | 5.76 | 0.00 | 0.00 | 51.45 |
| Other[b] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.03 |
| Totals | 0.00 | 0.00 | 3.87 | 18.64 | 6.15 | 11.72 | 0.00 | 0.04 | 5.30 | 5.76 | 0.00 | 0.00 | 51.48 |
| Antenna On/Off Cycles | 0 | 0 | 27 | 39 | 5 | 6 | 0 | 2 | 30 | 78 | 0 | 0 | 187 |

[a]Frequencies listed refer to the center frequency of modulation.

[b]Denotes short periods of time at other frequencies or undesignated operation.

TABLE J-4. 1987 OPERATIONS SUMMARY, NRTF-REPUBLIC: NORTH-SOUTH ANTENNA ONLY
(Hours of Operation)

| Frequency, Hz | Month: Ja | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | Annual Totals |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Mode: Modulated Signal[a] | | | | | | | |
| 76 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Subtotal | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | | | | | Mode: Unmodulated Signal | | | | | | | |
| 76 (15 Amps) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 44.40 | 27.59 | 32.40 | 38.86 | 33.08 | 21.79 | 0.00 | 198.12 |
| Subtotals | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 44.40 | 27.59 | 32.40 | 38.86 | 33.08 | 21.79 | 0.00 | 198.12 |
| Other[b] | 0.00 | 0.00 | 0.00 | 0.42 | 0.42 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.84 |
| Totals | 0.00 | 0.00 | 0.00 | 0.42 | 0.42 | 44.40 | 27.59 | 32.40 | 38.86 | 33.08 | 21.79 | 0.00 | 198.96 |
| Antenna On/Off Cycles | 0 | 0 | 0 | 1 | 1 | 533 | 331 | 389 | 466 | 397 | 262 | 0 | 2380 |

[a]Frequency listed refers to the center frequency of operation.

[b]Denotes small periods of time at other currents or undesignated operation.

TABLE J-5. 1987 OPERATIONS SUMMARY, NRTF-REPUBLIC: EAST-WEST ANTENNA ONLY
(Hours of Operation)

| Frequency, Hz | Month | | | | | | | | | | | | Annual Totals |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | |
| | | | | | | Mode: Modulated Signal[a] | | | | | | | |
| 76 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Subtotal | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | | | | | Mode: Unmodulated Signal | | | | | | | |
| 76 (15 Amps) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 43.95 | 27.81 | 32.39 | 38.61 | 33.94 | 21.90 | 0.00 | 198.60 |
| Subtotals | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 43.95 | 27.81 | 32.39 | 38.61 | 33.94 | 21.90 | 0.00 | 198.60 |
| Other[b] | 0.00 | 0.00 | 0.00 | 0.25 | 0.42 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.67 |
| Totals | 0.00 | 0.00 | 0.00 | 0.25 | 0.42 | 43.95 | 27.81 | 32.39 | 38.61 | 33.94 | 21.90 | 0.00 | 199.27 |
| Antenna On/Off Cycles | 0 | 0 | 0 | 1 | 1 | 527 | 334 | 389 | 463 | 407 | 263 | 0 | 2385 |

[a]Frequency listed refers to the center frequency of operation.

[b]Denotes small periods of time at other currents or undesignated operation.

TABLE J-6. 1988 OPERATIONS SUMMARY, NRTF-REPUBLIC: NORTH-SOUTH ANTENNA ONLY
(Hours of Operation)

| Frequency, Hz | Month | | | | | | | | | | | | Annual Totals |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | |
| | | | | | | Mode: Modulated Signal[a] | | | | | | | |
| 76 (75 Amps) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.27 | 0.14 | 0.00 | 0.00 | 0.00 | 0.00 | 3.41 |
| Subtotal | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.27 | 0.14 | 0.00 | 0.00 | 0.00 | 0.00 | 3.41 |
| | | | | | | Mode: Unmodulated Signal | | | | | | | |
| 76 (15 Amps) | 27.13 | 26.36 | 27.14 | 34.14 | 41.23 | 43.27 | 0.19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 199.46 |
| 76 (75 Amps) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 27.62 | 59.53 | 34.24 | 52.86 | 12.67 | 23.76 | 210.68 |
| 44 (75 Amps) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.27 | 0.00 | 26.16 | 2.61 | 31.20 | 15.68 | 76.92 |
| Subtotals | 27.13 | 26.36 | 27.14 | 34.14 | 41.23 | 43.27 | 29.08 | 59.53 | 60.40 | 55.47 | 43.87 | 39.44 | 487.06 |
| Other[b] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 8.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 8.09 |
| Totals | 27.13 | 26.36 | 27.14 | 34.14 | 41.23 | 43.27 | 40.44 | 59.67 | 60.40 | 55.47 | 43.87 | 39.44 | 498.56 |
| Antenna On/Off Cycles | 326 | 316 | 326 | 410 | 495 | 519 | 485 | 714 | 725 | 666 | 526 | 473 | 5981 |

[a]Frequency listed refers to the center frequency of operation.

[b]Denotes small periods of time at other currents or undesignated operation.

TABLE J-7. 1988 OPERATIONS SUMMARY, NRTF-REPUBLIC: EAST-WEST ANTENNA ONLY
(Hours of Operation)

| Frequency, Hz | Month | | | | | | | | | | | | Annual Totals |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | |
| | | | | | | Mode: Modulated Signal[a] | | | | | | | |
| 76 (15 Amps) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.32 | 0.14 | 0.00 | 0.00 | 0.00 | 0.00 | 3.46 |
| Subtotal | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3.32 | 0.14 | 0.00 | 0.00 | 0.00 | 0.00 | 3.46 |
| | | | | | | Mode: Unmodulated Signal | | | | | | | |
| 76 (15 Amps) | 27.14 | 30.95 | 31.48 | 34.34 | 41.33 | 43.13 | 0.22 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 208.59 |
| 76 (75 Amps) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 31.10 | 68.99 | 34.71 | 56.05 | 12.67 | 23.76 | 227.28 |
| 44 (75 Amps) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.06 | 0.00 | 26.38 | 2.52 | 31.29 | 15.58 | 76.83 |
| Subtotals | 27.14 | 30.95 | 31.48 | 34.34 | 41.33 | 43.13 | 32.38 | 68.99 | 61.09 | 58.57 | 43.96 | 39.34 | 512.70 |
| Other[b] | 0.00 | 0.00 | 0.00 | 0.25 | 0.42 | 0.00 | 7.20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7.20 |
| Totals | 27.14 | 30.95 | 31.48 | 34.34 | 41.33 | 43.13 | 42.90 | 69.13 | 61.09 | 58.57 | 43.96 | 39.34 | 523.36 |
| Antenna On/Off Cycles | 326 | 371 | 378 | 412 | 496 | 518 | 526 | 827 | 733 | 703 | 527 | 472 | 6289 |

[a]Frequency listed refers to the center frequency of operation.

[b]Denotes small periods of time at other currents or undesignated operation.

TABLE J-8. 1989 OPERATIONS SUMMARY, NRTF-REPUBLIC: NORTH-SOUTH ANTENNA ONLY
(Hours of Operation)

| Frequency, Hz | Month[a] Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | Annual Totals |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Mode: Modulated Signal[b] | | | | | | | |
| 44 | 0.00 | 0.00 | 0.00 | 0.00 | 0.19 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.20 |
| 76 | 0.00 | 0.00 | 0.00 | 0.00 | 6.91 | 0.00 | 0.00 | 0.05 | 0.85 | 0.00 | 19.00 | 0.00 | 26.81 |
| 78 | 0.00 | 0.00 | 0.00 | 0.00 | 0.32 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.32 |
| Subtotals | 0.00 | 0.00 | 0.00 | 0.00 | 7.42 | 0.00 | 0.01 | 0.05 | 0.85 | 0.00 | 19.00 | 0.00 | 27.33 |
| | | | | | | Mode: Unmodulated Signal | | | | | | | |
| 44 | 8.02 | 22.24 | 12.28 | 0.86 | 0.43 | 0.60 | 4.51 | 14.16 | 0.00 | 0.00 | 0.15 | 0.00 | 63.25 |
| 72 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.27 | 0.00 | 0.48 | 0.00 | 0.00 | 0.00 | 0.00 | 0.75 |
| 76 | 37.53 | 21.16 | 8.19 | 0.30 | 3.82 | 0.42 | 9.19 | 25.30 | 3.55 | 0.00 | 0.00 | 0.00 | 109.46 |
| 80 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.38 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.38 |
| Subtotals | 45.55 | 43.40 | 20.47 | 1.16 | 4.25 | 1.67 | 13.70 | 39.94 | 3.55 | 0.00 | 0.15 | 0.00 | 173.84 |
| Other[c] | 0.00 | 0.00 | 0.00 | 0.00 | 0.40 | 1.24 | 0.35 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 2.01 |
| Totals | 45.55 | 43.40 | 20.47 | 1.16 | 12.07 | 2.91 | 14.06 | 40.01 | 4.40 | 0.00 | 19.15 | 0.00 | 203.18 |
| Antenna On/Off Cycles | 547 | 521 | 245 | 2 | 30 | 73 | 9 | 24 | 97 | 1 | 7 | 0 | 1556 |

[a] 75 ampere antenna current used in Jan-Mar; 150 ampere antenna current used in Apr-Dec.

[b] Frequency listed refers to the center frequency of operation.

[c] Denotes small periods of time at other currents or undesignated operation.

TABLE J-9. 1989 OPERATIONS SUMMARY, WRTF-REPUBLIC: EAST-WEST ANTENNA ONLY
(Hours of Operation)

| Frequency, Hz | Month[a] | | | | | | | | | | | | Annual Totals |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | |
| | | | | | Mode: Modulated Signal[b] | | | | | | | | |
| 44 | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 | 0.20 | 0.29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.60 |
| 76 | 0.00 | 0.00 | 0.00 | 0.00 | 1.85 | 0.13 | 0.48 | 0.00 | 0.34 | 23.70 | 0.00 | 0.00 | 26.50 |
| 78 | 0.00 | 0.00 | 0.00 | 0.00 | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.13 |
| Subtotals | 0.00 | 0.00 | 0.00 | 0.00 | 2.09 | 0.33 | 0.77 | 0.00 | 0.34 | 23.70 | 0.00 | 0.00 | 27.23 |
| | | | | | Mode: Unmodulated Signal | | | | | | | | |
| 44 | 8.02 | 22.24 | 12.53 | 0.00 | 0.60 | 0.94 | 5.2 | 11.78 | 0.29 | 0.00 | 0.00 | 0.00 | 61.60 |
| 72 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.82 | 0.52 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.34 |
| 76 | 37.56 | 21.16 | 8.11 | 2.65 | 4.78 | 1.57 | 9.22 | 17.83 | 13.68 | 0.00 | 0.00 | 0.00 | 116.56 |
| 80 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.59 | 0.85 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.44 |
| Subtotals | 45.58 | 43.40 | 20.64 | 2.65 | 5.38 | 3.92 | 15.79 | 29.61 | 13.97 | 0.00 | 0.00 | 0.00 | 180.94 |
| Other[c] | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | 0.99 | 2.16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.15 |
| Totals | 45.58 | 43.40 | 20.64 | 2.65 | 7.47 | 4.25 | 16.56 | 29.61 | 14.31 | 23.70 | 0.00 | 0.00 | 212.32 |
| Antenna On/Off Cycles | 548 | 521 | 246 | 1 | 32 | 70 | 57 | 17 | 70 | 2 | 13 | 1 | 1578 |

[a]75 ampere antenna current used in Jan-Mar; 150 ampere antenna current used in Apr-Dec.

[b]Frequency listed refers to the center frequency of operation.

[c]Denotes small periods of time at other currents or undesignated operation.

TABLE J-10. 1989 OPERATIONS SUMMARY, NRTF-REPUBLIC: NORTH-SOUTH AND EAST-WEST ANTENNAS SIMULTANEOUSLY
(Hours of Operation)

| Frequency, Hz | Month[a] Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | Annual Totals |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Mode: Modulated Signal[b]** | | | | | | | | | | | | | |
| 44 | 0.00 | 0.00 | 0.00 | 0.00 | 23.99 | 26.03 | 69.78 | 51.97 | 0.00 | 0.36 | 0.00 | 0.00 | 172.13 |
| 76 | 0.00 | 0.00 | 0.00 | 0.00 | 56.09 | 0.84 | 96.42 | 229.01 | 345.51 | 679.61 | 690.11 | 743.38 | 2840.97 |
| 78 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.32 | 0.00 | 0.00 | 0.35 |
| Subtotals | 0.00 | 0.00 | 0.00 | 0.00 | 80.11 | 26.87 | 166.2 | 280.98 | 345.51 | 680.29 | 690.11 | 743.38 | 3013.45 |
| **Mode: Unmodulated Signal** | | | | | | | | | | | | | |
| 44 | 0.35 | 1.12 | 0.61 | 4.30 | 119.33 | 76.04 | 82.41 | 49.14 | 7.18 | 0.00 | 0.47 | 0.00 | 340.95 |
| 72 | 0.00 | 0.00 | 0.00 | 0.00 | 0.42 | 1.64 | 0.46 | 0.02 | 0.07 | 0.00 | 0.00 | 0.00 | 2.61 |
| 76 | 1.04 | 1.84 | 7.37 | 2.95 | 125.65 | 389.56 | 354.51 | 121.39 | 164.37 | 9.70 | 4.97 | 0.00 | 1183.35 |
| 80 | 0.00 | 0.00 | 0.00 | 0.00 | 6.05 | 24.75 | 0.00 | 46.03 | 0.09 | 0.00 | 0.00 | 0.00 | 76.92 |
| Subtotals | 1.39 | 2.96 | 7.98 | 7.25 | 251.45 | 491.99 | 437.38 | 216.58 | 171.71 | 9.70 | 5.44 | 0.00 | 1603.83 |
| Other[c] | 0.00 | 0.00 | 0.00 | 0.00 | 1.30 | 6.90 | 4.09 | 1.69 | 0.00 | 29.69 | 4.68 | 0.00 | 48.35 |
| Totals | 1.39 | 2.96 | 7.98 | 7.25 | 332.86 | 525.76 | 607.67 | 499.25 | 517.22 | 719.68 | 700.23 | 743.38 | 4665.63 |
| Antenna On/Off Cycles | 24 | 24 | 16 | 2 | 73 | 125 | 110 | 88 | 145 | 80 | 68 | 55 | 810 |

[a]75 ampere antenna current used in Jan-Mar; 150 ampere antenna current used in Apr-Dec.

[b]Frequency listed refers to the center frequency of operation.

[c]Denotes small periods of time at other currents or undesignated operation.

TABLE J-11. 1990 OPERATIONS SUMMARY, NRTF-REPUBLIC: NORTH-SOUTH ANTENNA ONLY
(Hours of Operation)

| Frequency, Hz | Month[a] Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | Annual Totals |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mode: Modulated Signal[b] | | | | | | | | | | | | | |
| 76 | 0.43 | 0.10 | 15.98 | 5.20 | 2.15 | 0.55 | 5.08 | 105.23 | 2.78 | 19.78 | 0.00 | 0.03 | 157.31 |
| Subtotals | 0.43 | 0.10 | 15.98 | 5.20 | 2.15 | 0.55 | 5.08 | 105.23 | 2.78 | 19.78 | 0.00 | 0.03 | 157.31 |
| Mode: Unmodulated Signal | | | | | | | | | | | | | |
| 76 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 80 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Subtotals | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Other[c] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Totals | 0.43 | 0.10 | 15.98 | 5.20 | 2.15 | 0.55 | 5.08 | 105.23 | 2.78 | 19.78 | 0.00 | 0.03 | 157.31 |
| Antenna On/Off Cycles | 4 | 1 | 3 | 4 | 2 | 1 | 2 | 6 | 5 | 1 | 0 | 1 | 30 |

[a]150 ampere antenna current used throughout 1990.

[b]Frequency listed refers to the center frequency of operation.

[c]Denotes small periods of time at other currents or undesignated operation.

TABLE J-12. 1990 OPERATIONS SUMMARY, NRTF-REPUBLIC: EAST-WEST ANTENNA ONLY
(Hours of Operation)

| Frequency, Hz | Month[a] Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | Annual Totals |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mode: Modulated Signal[b] | | | | | | | | | | | | | |
| 76 | 0.00 | 3.16 | 20.90 | 1.42 | 0.62 | 0.73 | 0.07 | 0.50 | 8.65 | 0.00 | 0.00 | 0.05 | 36.10 |
| Subtotals | 0.00 | 3.16 | 20.90 | 1.42 | 0.62 | 0.73 | 0.07 | 0.50 | 8.65 | 0.00 | 0.00 | 0.05 | 36.10 |
| Mode: Unmodulated Signal | | | | | | | | | | | | | |
| 76 | 0.00 | 0.00 | 0.00 | 115.74 | 80.71 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 196.45 |
| 80 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Subtotals | 0.00 | 0.00 | 0.00 | 115.74 | 80.71 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 196.45 |
| Other[c] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Totals | 0.00 | 3.16 | 20.90 | 117.16 | 81.33 | 0.73 | 0.07 | 0.50 | 8.65 | 0.00 | 0.00 | 0.05 | 232.55 |
| Antenna On/Off Cycles | 75 | 14 | 5 | 89 | 73 | 4 | 1 | 0 | 5 | 0 | 0 | 1 | 267 |

[a]150 ampere antenna current used throughout 1990.

[b]Frequency listed refers to the center frequency of operation.

[c]Denotes small periods of time at other currents or undesignated operation.

TABLE J-13. 1990 OPERATIONS SUMMARY, NRTF-REPUBLIC: NORTH-SOUTH AND EAST-WEST ANTENNAS SIMULTANEOUSLY
(Hours of Operation)

| Frequency, Hz | Month[a] | | | | | | | | | | | | Annual Totals |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | |
| | | | | | | Mode: Modulated Signal[b] | | | | | | | |
| 76 | 699.75 | 606.50 | 636.26 | 542.87 | 612.78 | 684.44 | 704.67 | 591.42 | 659.63 | 678.11 | 674.35 | 702.78 | 7793.56 |
| Subtotals | 699.75 | 606.50 | 636.26 | 542.87 | 612.78 | 684.44 | 704.67 | 591.42 | 659.63 | 678.11 | 674.35 | 702.78 | 7793.56 |
| | | | | | | Mode: Unmodulated Signal | | | | | | | |
| 76 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.45 | 0.00 | 0.00 | 0.00 | 0.00 | 0.45 |
| 80 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.47 | 0.00 | 0.00 | 0.00 | 0.00 | 4.47 |
| Subtotals | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.92 | 0.00 | 0.00 | 0.00 | 0.00 | 4.92 |
| Other[c] | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Totals | 699.75 | 606.50 | 636.26 | 542.87 | 612.78 | 684.44 | 704.67 | 596.34 | 659.63 | 678.11 | 674.35 | 702.78 | 7798.48 |
| Antenna On/Off Cycles | 30 | 19 | 18 | 88 | 71 | 41 | 15 | 27 | 13 | 12 | 17 | 33 | 384 |

[a]150 ampere antenna current used throughout 1990.

[b]Frequency listed refers to the center frequency of operation.

[c]Denotes small periods of time at other currents or undesignated operation.